THE *Petroleum* Engineer — **Management Edition**

Exploration—Drilling—Producing • Refining—Petrochemicals—Gas Processing • Oil and Gas Pipelining

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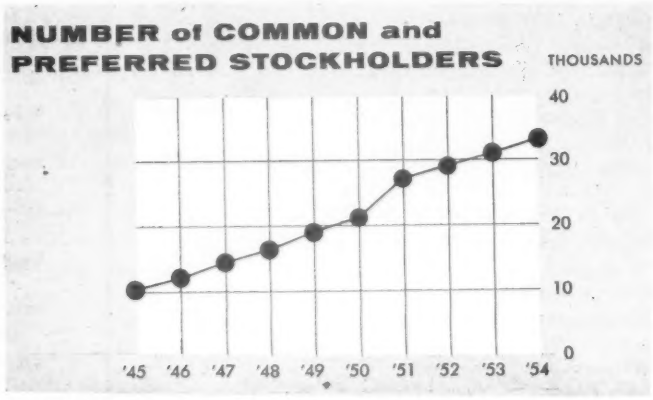
From Blue Sky to Blue Chips

THERE may be some doubt in the minds of the public about whether they "know the petroleum industry" or whether they "like us," but there is no question that oil company stocks appeal to the investing public.

The Petroleum Engineer survey of annual reports shows that more people than ever before own shares in the oil and gas industry. Several oil companies are among the top ten in number of stockholders. After American Telephone and Telegraph Company and General Motors, comes Jersey Standard, with 270,000 owners of common stock, the third largest number among U. S. companies. Cities Service, Socony-Vacuum, Standard of Indiana, Standard of California, Sinclair, The Texas Company, Phillips, Sunray, and Gulf each has more than 60,000 persons or organizations as shareholders.

It is a significant trend – this widespread ownership – and highly important to the industry. A man or woman who owns one share of stock in a petroleum company is not indifferent to its progress.

The oil industry has come a long way from the days when it stood about where the uranium exploration industry does now. Oil shares have gone from "blue sky" to "blue chips." Many companies are on the "investment" lists of financial analysts. A majority of the industry's traded stocks are highly regarded by brokers.



In Sohio's annual report is this graph showing how number of stockholders have more than tripled in nine years.

There are still speculative oil stocks with wide fluctuations and consequent higher gains or losses but the overall oil market is considered more stable than ever before and attracts more investors.

Values of most oil stocks on the exchanges have risen steadily in the last few years. In 1954, despite the fall off in net gain, virtually every oil company's shares increased in value, some spectacularly. Stockholders' equity has shown a steady rise.

This can hardly be called inflation because in 1954 the U. S. industry spent $5 billion or more to find and develop supplies and to purchase facilities for processing, transporting, storing, and marketing oil and gas. A substantial part of this sum comes from earnings.

Dividends are small proportionately but the investment in reserves and facilities for expanded operations means a dynamic, confident, and experienced industry with an eye on tomorrow.

Ernestine Adams

FOR PIPE LINE CONSTRUCTION

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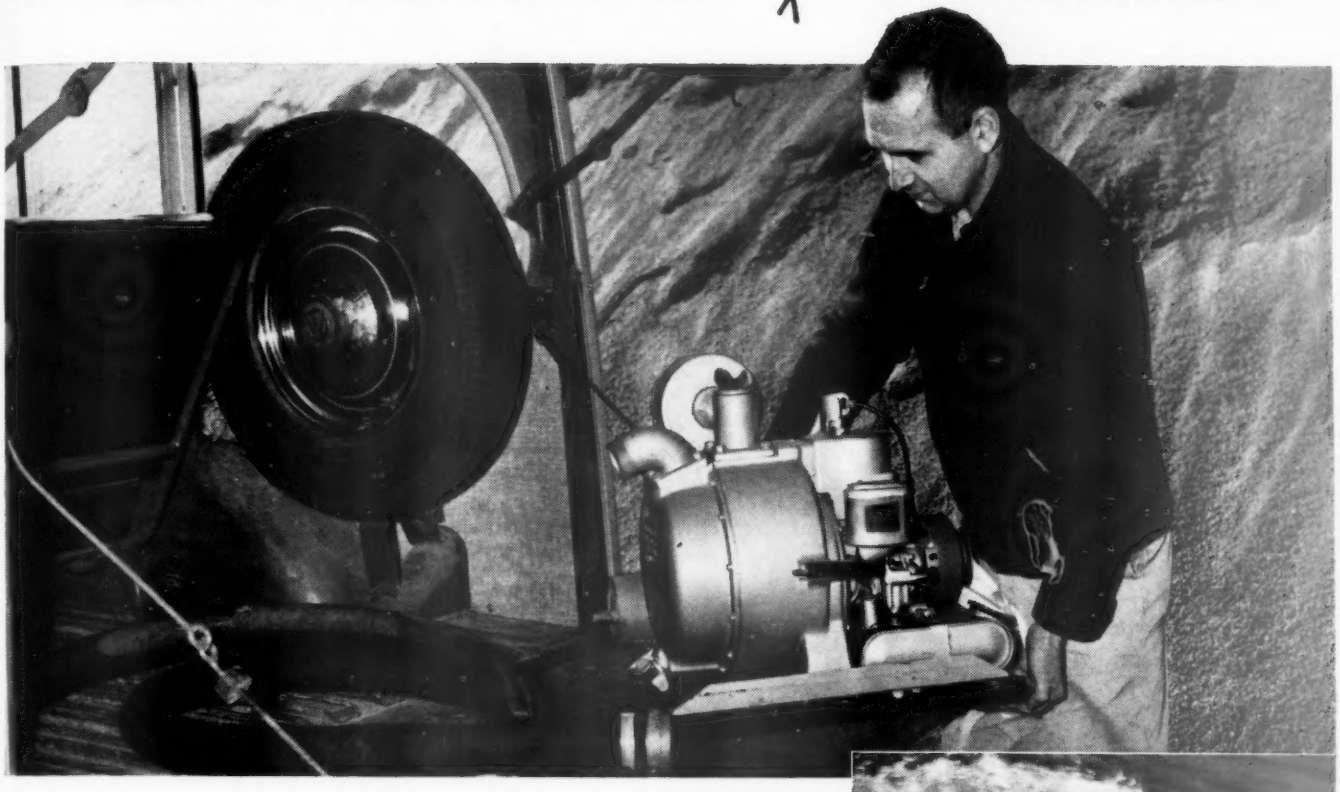

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To obtain more information on products advertised see Page E-41

XUM

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Ten gas-producing companies have been ordered by the Kansas Corporation to show cause why more gas has not been purchased from the Hugoton field in the southwestern part of the state. Hearing has been set for May 16. Commission officials feared unbalanced drainage of the field because of larger withdrawals from Oklahoma and Texas Panhandle sides of the field.

★ ★ ★

Senate approval of the Neely amendment may be affected negatively by a 20-page state department memorandum discouraging its passage. The amendment would establish a fixed import quota. The memo suggested that such legislation would be difficult to change in emergencies, as well as discourage peaceful settlement of the problem by the industry itself, and cause "embarrassment and hard feelings" toward us by other countries.

★ ★ ★

Coal lost ground to oil and gas by 20 per cent in the last four years according to the Bureau of Mines. Oil and gas now dominate fuel supply, providing 66.8 per cent of the usable energy from mineral fuel and water power in 1954 against coal's 29.3 per cent. In 1950 coal supplied 40.5 per cent of the total, and in 1900 88.9 per cent.

★ ★ ★

Union Oil of California has been slow to find a buyer for an announced sale of 1,000,000 bbl of crude. The surplus oil had resulted from a special situation of temporary nature, according to West Coast officials. Several companies have expressed interest in the offer, although many claim they have not been contacted.

★ ★ ★

Oilmen have a real public relations problem on their hands today, A. L. Solliday, executive vice president of Stanolind told production men in API's Rocky Mountain division recently. We have done a good job in finding and producing oil and gas and in turning them into useful products but "we have failed to explain the nature of our business, its risks and hazards." Solliday said that the industry has neglected to answer charges made against it, and let misinformation creep in.

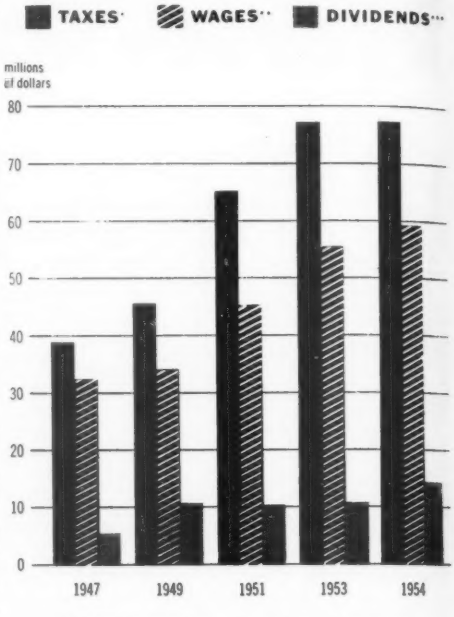
If natural gasoline is to compete satisfactorily with improved motor fuels now on the market, new methods must be found for economic upgrading. Refiners are working to solve similar problems of volume production involving light crude fractionation, refining executives told members of the Natural Gasoline Association of America in annual session at Dallas, Texas, recently.

★ ★ ★

To compensate for reductions in purchasers' nominations to buy Texas crudes for May, the state trimmed its May allowables 214,195 bbl to 3,072,150 bbl daily. Texas wells will produce on a 16-day schedule for the coming month. Railroad Commission will establish allowables for June and July at a special meeting in May. Louisiana Conservation Commission reported its May proration would remain unchanged from the April allowable.

★ ★ ★

LP-Gas usage in trucks, buses, stationary engines and lift trucks increased by 42 per cent last year, final tabulations by the Liquefied Petroleum Gas Association show. The Association's survey also revealed that some 197,000 tractors were running on butane or propane, 23 per cent more than the total for the previous year.



**Includes gasoline and other sales taxes.*
***Includes employees' benefits.*
****Excludes share dividend paid in 1953 of 1 share for each 10 shares outstanding.*

In its annual report Union Oil Company of California shows in this graph what one company pays in local, state and federal direct and excise taxes in comparison with the pay and benefits to employees and dividends to shareholders. Other findings from an annual report survey begins on Page A-63.

ROAD TO LEARNING

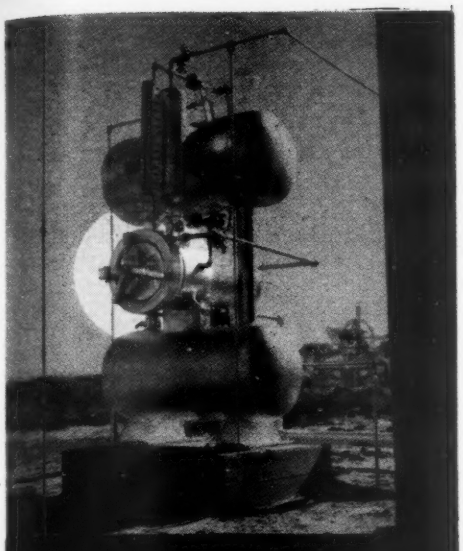
Desk and Derrick Clubs have launched another method of acquiring information about the oil industry—this time the intensive seminar method. The short courses are given in cooperation with universities, the lecturers chosen both from the university and the industry.

Los Angeles Desk and Derrick Club held a one-day seminar at UCLA, May 7. Dallas, Texas, Desk and Derrick Club in cooperation with Southern Methodist University will hold a short course for 400 members from Texas, New Mexico, Arizona, and Arkansas, June 3-5. New Orleans members have one June 3-5 at Tulane University for the Southeast district.

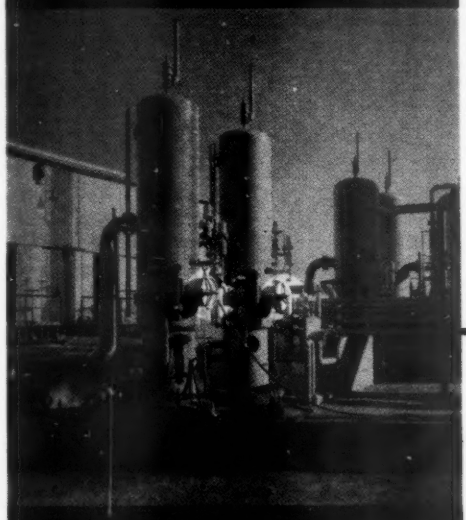
Oklahoma Desk and Derrick Club is sponsoring a seminar at Oklahoma University, Norman, June 11-12. This will include members from Oklahoma and Kansas.

Oklahoma City Desk and Derrick Club was the first one to hold a seminar. Like the one planned this June, it was held at Oklahoma University where the hundred members who attended stayed in dormitories at the university extension quarters. Lectures were given throughout the two days, a concentrated review of oil and gas operations, with question periods.

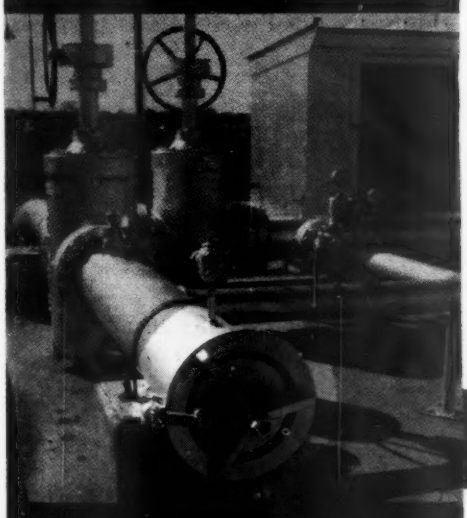
In 1954, Tulsa Desk and Derrick Club sponsored a seminar at Tulsa University with another program of lectures of high caliber. The enthusiasm generated by the two Oklahoma courses spread this year to Louisiana, Texas, and California. It is clear, Desk and Derrick members approve this intensive road to learning.



It's no effort at all to reach the internals of this Peerless Gas Odorizer through the Sillers Flex-Ring Closure.



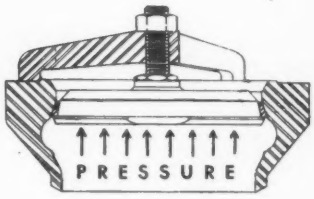
Sillers Flex Ring Closures are utilized on these large scrubbers at a Field Processing Plant in South Texas.

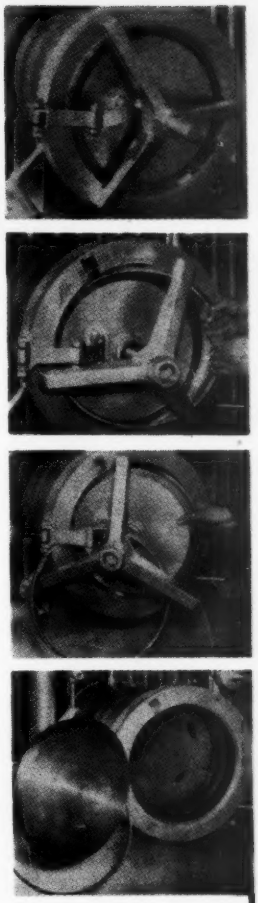


Here is a typical Sillers Flex Ring Closure installation on a Sillers Scraper trap on a products pipeline in Eastern Oklahoma.

SILLERS FLEX RING CLOSURE

for faster access to the inside of pressure vessels or piping . . .





(1). Flex Ring Unit assembled as in service. (2). Spider released, gasket being removed. (3). After gasket is removed, plug is rotated to open. (4). Unit completely opened and in a fraction of time taken for conventional type closures.

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SILLERS ENGINEERING COMPANY

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Representatives in Principal Cities

Shell Development Company has installed a 2,000,000-volt atom-smasher at its Houston, Texas, research division. The unit will be used as an analytical tool and in exploration and production research to duplicate nature's own radioactive processes relative to oil formation.

★ ★ ★

Geophysical activity in the United States and Canada last year dipped below the record set in 1953. Overall decrease in the use of seismic crews was responsible for the decrease. Exploration by gravity methods showed a marked rise, according to figures released by the Society of Exploration Geophysicists.

★ ★ ★

Sapphire Petroleums has begun uranium exploration work on a 160,000-acre tract in Colorado Plateau area of New Mexico. Lease was awarded to Sapphire, acting with several other companies, by the Acoma Pueblo Indians in February. Other interests include White Eagle Oil Company, Panhandle Oil Corporation and Freeport Sulphur Company.

★ ★ ★

Sinclair has withdrawn from the Iranian Consortium and assigned its rights to Richfield Oil Corporation, its affiliate. While the company's unit interest was so small to be "uninteresting," the addition to Richfield's existing interest should place the affiliate in a much stronger position to make the venture effective and profitable, company officials said.

★ ★ ★

State of Oklahoma has been refused the right to regulate processed natural gas sold into out-of-state pipelines by an April Supreme Court ruling. Natural Gas Pipeline Company, a gas buyer for Phillips Petroleum and Panoma Corporation, had questioned an Oklahoma Corporation Commission ruling which boosted the minimum price from 7 to 9.8262 cents per 1000 cu ft.

★ ★ ★

Seasonal slump in fuel demand has brought about cuts in refinery runs by several of the majors. Continental Oil has set a 11.3 per cent decrease for the second quarter of 1955. Cities Service is trimming its Oklahoma crude purchases in April to 70 per cent of that run in February. Standard of Indiana will cut its runs to the stills by 8 per cent in April and May. Humble will reduce May refinery operations 20,000 bbl daily.

★ ★ ★

Future of the Federal highway program looks dark, as financing problems increase. Comptroller General Campbell has questioned the legality of using the federal gasoline tax for the explicit purpose of highway financing; accordingly, legislation has been proposed to eliminate the tax entirely and let the states handle their own highway projects. Other bills, however, would increase the gas tax.

★ ★ ★

Construction in the gas utilities and pipe line industry will exceed a billion dollars this year, American Gas Association estimated. New construction and several projects planned earlier but deferred until this year has upped the original outlay to make it the second largest expansion year in the industry's history. Continued natural gas regulation could mean a downward revision of this figure.

★ ★ ★

American Farm Bureau Federation and five other leading farmer-stockmen associations, are taking an active stand against natural gas regulation. The Bureau's statement made before the House Commerce Committee held that since substantial gas reserves lie beneath farms, any encroachment by the government into price regulation in the field would be detrimental to the concept of private ownership as well as harmful to consumer interests.

★ ★ ★

If auto production goes hand in hand with petroleum consumption, the industry is in for a record year. Passenger car assemblies totaled 3,000,000 by first week in May Last year only 2,000,000 vehicles were completed in the same period.

★ ★ ★

Shell Chemical Corporation is setting up three new chemical plants at Norco, Louisiana for commercial production of hydrogen peroxide, glycerine and acrolein. Work on the first plant, to produce more than 30,000,000 lb of hydrogen peroxide yearly, is to begin immediately. Plants will involve processes innovated by Shell Development making use of refinery waste gases.

The City of Long Beach, in a 4-to-3 decision on April 5, by the California Supreme Court, was denied the right to use surplus oil tideland funds for other than harbor development projects.

★ ★ ★

Alan F. Griffith, petroleum engineering student at the University of Oklahoma, has been chosen as the winner of the American Institute of Mining, Metallurgical and Petroleum Engineers' district student paper contest conducted at the University of Tulsa.

★ ★ ★

A federal grand jury is looking into recent "irregular" gasoline price fluctuations in New Jersey for restraint of trade or illegal price fixing. Sharp price hikes, accentuated by intermittent price cutting, picketing and a retailer group merger have brought action by the Department of Justice anti-trust division.

★ ★ ★

Humble, Gulf and Texas Company have begun joint operation of a $7,500,000 natural gas cycling plant at Krotz Springs, Louisiana. Processing of 100,000,000 cu ft of gas per day can be handled when plant reaches full operation.

★ ★ ★

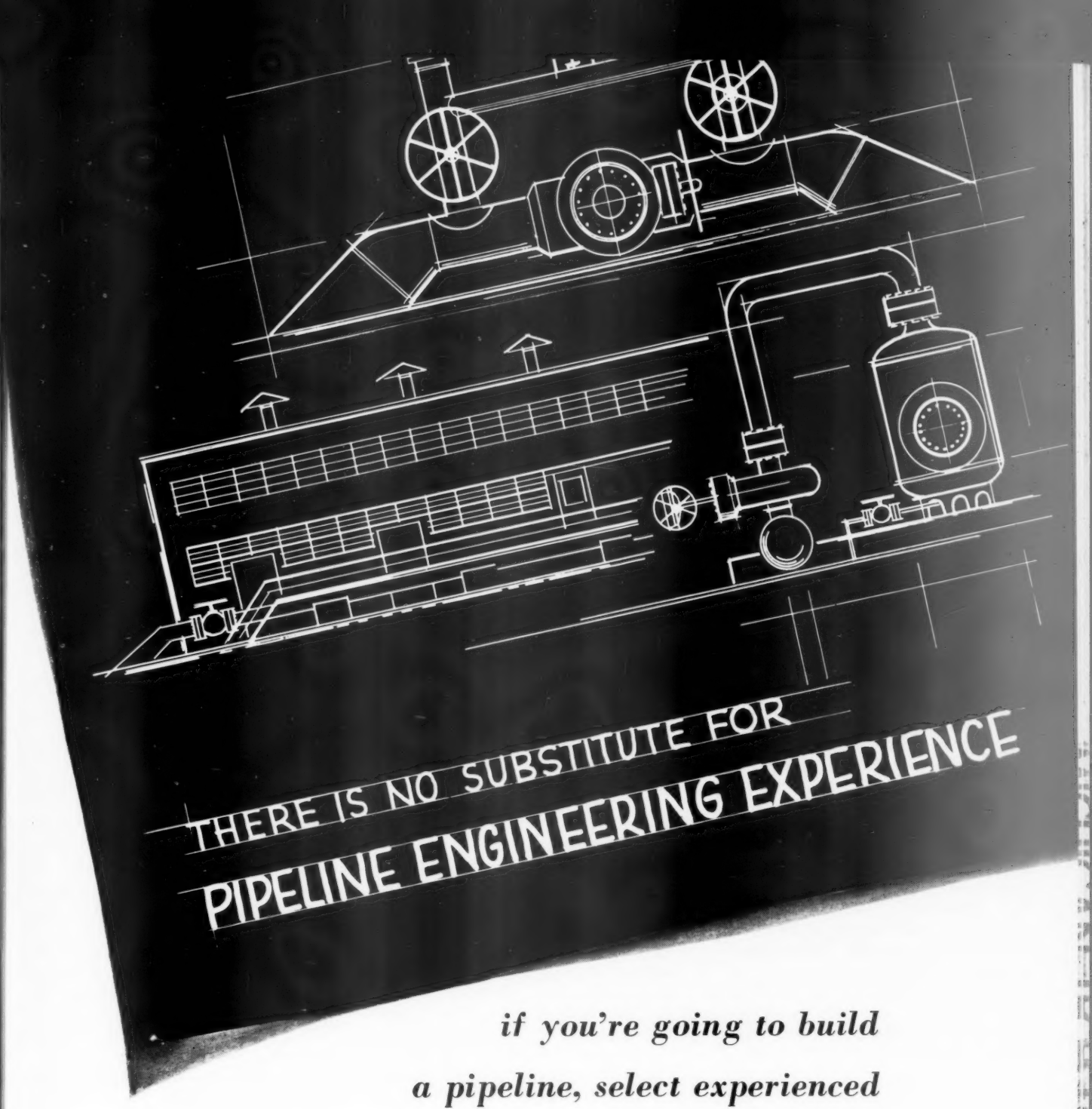
Alaska legislature passed bills establishing an oil and gas conservation commission, and defined and prohibited oil and gas waste. Utah has designated its state land board as its conservation group. Wyoming, South Dakota, and Nevada state bodies have voted regular membership in the Interstate Oil Compact Commission.

★ ★ ★

Agreement has been reached between the Interior Department and the State of California permitting geological and geophysical exploration in Outer Continental Shelf under state supervision. It is similar to agreements signed earlier with Texas and Louisiana. Negotiations on exploration agreements also are under way with Florida and Mississippi.

★ ★ ★

American Association of Petroleum Landmen met in Fort Worth, Texas, April 28-30 to chart the future of the new organization. At the initial sessions, the group heard Arkansas' Rep. Oren Harris and Sinclair President P. S. Spencer. The association has already enlisted over 800 members from 23 states.



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Petroleum Profile

So this was the petroleum industry! The young roustabout hacked away at the brush about him. For this he got $60 a month—no board. As he dragged back to camp, dusty and sweaty, muscles aching after a 10-hour day, he felt discouraged.

Here he was 22, with a degree in geology and mining, and the only job the oil industry could offer was that of an unskilled laborer. Al Peake himself didn't even dream then that he would one day be president of the nation's third largest oil company.

Alonzo W. Peake had been born in Kansas City, the youngest of two sons of a dry goods and haberdashery merchant. His route to school took him along a branch of the Santa Fe trail, over which his father as a young man had driven freight wagons into New Mexico.

Vacations meant the joys of fishing with a home-made pole along the Missouri River—a hobby he never would outgrow.

The Peakes moved to Azusa, California, while the boy was in his teens. He finished high school there.

Working as waiter, cook, janitor, and draftsman, he earned his way through Stanford University. He won his letter in track, completed his studies in three and a half years and was graduated in 1912.

After a few months in the San Francisco office of a petroleum and mining engineer consultant, young Peake turned south for some experience in the oil fields being developed in Ventura County.

The Montebello Oil Company needed no geologist, but there were some roustabout jobs open, if a young fellow was willing to start at the bottom. It was rock-bottom—and the job was cutting brush to clear off sites for drilling new wells.

Promotions came along: Pumper, tool dresser, lease foreman, then assistant field superintendent.

Midwest Refining Company engaged him as superintendent in Wyoming's Big Muddy oil field in 1916. In the next 12 years he rose to superintendent of the gas department, chief engineer of the field division, and general superintendent of production. In the latter job he was in charge of building a 25,000-kw electric generating plant for the electrical operation of the 22,000-acre Salt Creek field in Natrona County, Wyoming. He was

A. W. Peake

one of the assets Standard Oil of Indiana acquired when it bought Midwest Refining in 1921. Five years later Peake became a director of Midwest.

When, in 1928, Standard's directors needed a president for a production subsidiary in the South and Southwest, the Dixie Oil Company, they chose A. W. Peake.

Two years later he went to Chicago as a director of Standard and vice president in charge of production. In that position, he directed for years the extensive crude producing, purchasing, and transportation operations of the company's Stanolind subsidiaries.

In 1945 Peake was elected president of Standard Oil. He has directed all the company's operating departments since then. In the period to 1954 Standard's consolidated total assets soared from $940 million to more than $2 billion; production of crude oil and natural gas liquids increased from 179,400 bbl daily to 249,600; refinery throughput went up from about 320,700 bbl a day to 579,500; sales increased from $601.5 million to more than $1.6 billion.

Peake's longtime friend and 40-year team mate in Standard's top management, Dr. Robert E. Wilson, chairman, said recently:

"As a business associate, Al's main characteristics are his forthrightness and his ability to spot the weak points in a situation or an organization. There is never any doubt as to where he stands on a given subject; but he retains an open mind, and, if convinced that he is mistaken, he is prompt to admit it."

Peake has also been a director of The American Oil Company, a Standard subsidiary; Continental Illinois National Bank and Trust Company, Chicago; the American Petroleum Institute; and the Chicago Association of Commerce and Industry. He is on the National Advisory Board of Junior Achievement and a former Northwestern University trustee. During World War II he served on the Petroleum Administration for War board.

On May 3, at 65 he retired as president, to be succeeded by Frank O. Prior, executive vice president. Two days later he gave up the directorship he has held for 25 of the 34 years he has served Standard and subsidiaries.

But, like the young roustabout, he won't quit working. He'll open a petroleum consulting office in San Francisco.

"I don't want *too* much business," he told a reporter recently, explaining that he wants a little time for hunting and fishing—and to play with his grandchildren in California.

The Petroleum ENGINEER

MAY 1955

U. S. Oil Companies Pass $5 Billion Mark for Annual Capital Expenditures

Ernestine Adams*

1954 ANNUAL REPORTS SHOW

- **Gross Income 4% Higher**
- **Smaller Net Income**
- **2% Cut in Direct Taxes**
- **More Excise Taxes Collected**
- **Number Shareholders Increase**
- **Stockholders Equity Larger**
- **Employment Slightly Up**
- **Payroll and Benefits Higher**
- **Capital Assets Larger**
- **Expenditure Trend Still Up**

IN 1954, for the first time, the U. S. petroleum industry paid out more than $5 billion for capital investments. This money went to explore for and develop oil and gas reserves, construct and expand processing plants, build pipe lines, tankers and terminals, both in the United States and abroad.

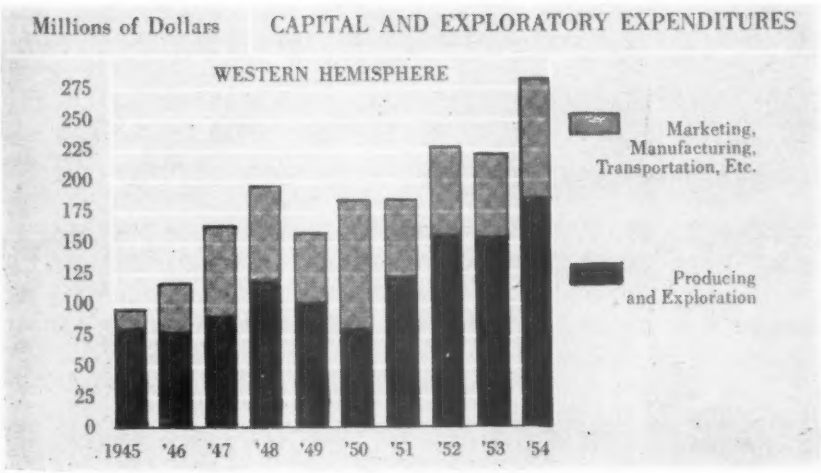
Indications are that 1955 will see yet higher expenditures, probably from $5¼ to $5½ billions. These will come primarily from the companies with large interests abroad, except in isolated cases like Tide Water Associated Oil Company, which plans to double capital investment in 1955. On the other hand, a survey of annual reports of operating oil corporations on stock exchanges shows that the smaller independents are spending more than the big companies in proportion to their net earnings. This is probably also true of companies individually owned, which do not release financial reports.

*Management Editor.

The prosaic figures form a picture of a huge, expanding, vital industry with dynamic management in a highly competitive field.

Why does the oil industry spend so much to expand its supply and capacity at a time when there is an excess in domestic crude oil producibility and refining capacity? Socony-Vacuum answers that question with: "The main reason is that we anticipate continued growth in the use of oil. In an industry as vital and dynamic as petroleum, companies must act in response to future as well as present considerations. Money must be spent now to provide equipment and sources of supply we will need several years hence."

The Shell report indicates the results of a planned expansion with: "The large postwar capital expenditure program has made it possible for your company to keep pace with both the industry-wide expansion and the increasing public acceptance of its products. Effects of these investments may be measured by the 197 and 249 per cent increases, respectively, in 1954 sales revenue and net income over those of 1946. It is expected that the level of capital expenditures in 1955 will be about the same as last year, but should decline in 1956."



Standard of California graph shows how it has increased capital investment since 1945.

THANKS, UNCLE SAM

Gross total income for the companies under study was about 4 per cent higher in 1954 than in 1953, due somewhat to slightly higher crude oil prices, to marketing emphasis on special products, to

TABLE 1. FINANCIAL STATISTICS FOR 1954 TAKEN FOR OIL COMPANY ANNUAL REPORTS

Company	No. years in business	Gross income 1954 ($1000)	Gross income per cent of 1953	Net income 1954 ($1000)	Net income per cent of 1953	Direct taxes ($1000) 1954	Direct taxes ($1000) 1953	Taxes collected for govts. ($1000)	No. shareholders of common stock	Common stock 1000 shares	Price per share Dec. 31, 1954	Net income per share	Direct taxes per share	Dividends per share	Number employees 1954	Number employees 1953	Payroll & benefits ($1000) 1954	Payroll & benefits ($1000) 1953	Net capital assets ($1000)	Working capital ($1000)	Depreciation, depletion and intangibles ($1000)	Capital expenditures ($1000) 1953	Capital expenditures ($1000) 1954	Capital expenditures ($1000) 1955
*Amerada Petroleum	34	84,996	99	19,778	107				6,046	3,155	$227½	$ 6.27	$	$3.00										
Anderson-Prichard	39	54,865	103	3,254	73	998	2,413			813	49	4.00	1.23	1.60					68,485	31,925	34,549	42,675	43,025	
Argo Oil Corp.		10,156	111	4,289	102	981	539			2,000	26½	2.14	.49	1.00					39,972	6,129	4,960	13,248	9,536	
*Ashland Oil & Ref	31	227,948	96	6,628	79	8,018	9,360	21,615	30,788	5,427	14	.92	1.48	1.00					19,505	1,176	2,648	4,360	4,599	
*Atlantic Refining Co.	84	596,168	98	41,351	83	24,889	25,152	64,195	45,271	8,962	39¼	4.47	2.78	2.00	4,200	4,400	21,951	22,424	73,015	45,687	13,753	23,791	11,130	10,000
*Bishop Oil Co.	28	1,864	102	309	106				700	383	14	.81		.22½†	21,191	21,188	101,656[2]	99,454[2]	407,821	93,384	39,245	82,129	68,318	67,600
*British-American	48	236,874	109	18,159	92	24,000	24,060	40,000	25,659	8,412	30½	2.16	2.80	.85	85	85			3,638	106	376	578	1,169	1,000
*Cities Service	45	813,174	97	43,724	86	28,827	51,900			3,965	123¼	11.02		5.00	5,318	5,101	25,933	24,091	144,882	58,276	13,707	33,603	32,130	higher
*Continental Oil	79	500,125	105	41,683	102	20,184	25,574	52,067	29,150	9,747	75	4.28	2.07	2.60					606,535	315,278	57,411	131,275	105,000	
*Cosden Petroleum[4]	17	45,040	117	2,814	120	1,733	1,221	7,177	2,750	810	26⅞	3.47	2.13	1.00†	9,348	9,183	54,540	50,812	269,243	114,205	66,693	84,968	100,044	
*Deep Rock Oil	56	38,685	92	2,481[1]	162	2,747	609	4,441	1,841	422	47¾	5.88	6.51	.50†	613	549	2,987	2,639	15,246	3,848	1,233	4,700	5,330	3,000
*Delhi-Taylor Oil	9	53,848[5]		916					8,500	5,363	16¼				843	991	5,319	5,621	27,336	13,743	2,161	4,502	6,425	795
*Douglas of Calif.	25	21,387	101	368	57	338	528	4,558	1,024	1,151	4½	.32	.29	.10	576	—			43,725	11,198	3,875			
*Drilling & Exploration	26	9,891	105	1,216	89	120				1,896	9⅞	.64			332	333	1,447	1,144	5,594	1,557	632	1,487	1,131	600
*General American	18	13,922	102	6,573	122	1,086	843		1,775	1,194	50¼	5.46	.91	.60			198		11,361	3,839	2,219	3,581	3,000	
*Gulf Oil Corp.	54	1,721,211	104	182,813	104	139,722[6]	135,361[6]	237,942	69,140	25,534	66[4]	7.16	5.47	2.00†	350	332	1,702	1,706	28,864	9,082	5,116	7,373	1,680	
*Hancock Oil Co.	32	41,174	84	6,880	57	621	657	8,999	3,850	3,113	38½	1.20	.20	.60†	46,800[7]	48,000[7]	224,867[8]	219,879[8]	1,969,052	391,636	143,594	221,598	292,032	
Honolulu Oil Co.	45	30,776	104	10,236	101	3,520	3,542		3,772	1,875	83½	5.46	1.88	2.50	428	325			2,755	32,115	2,070	595	768	5,200
Houston Oil Co.	54	32,706	100	6,488	97	3,074	3,655		3,566	1,342	110	4.83	2.29	2.25	499	489	3,551	3,310	47,836	12,945	4,703	9,300	11,800	114,500
*Husky Oil Co.[4]	16	13,741	152	1,004	171	415	372			2,338	7⅞	.34	.18		724	729	4,172	3,782	69,767	6,826	5,143	11,299	8,337	115,550
*Kerr-McGee Oil		32,371	100	2,360	88	875	683			317	48½	7.43	2.76	1.20	239	226	1,535	1,443	13,171	3,126	1,809	2,550		
Lion Oil Co.	32	98,585	110	11,071	104	7,547	8,031	10,506	16,807	3,091	48⅞	3.58	2.44	2.00	2,992	2,732	16,547	14,990	29,953	2,308	3,173	8,162	12,278	
Louisiana Ld. & Exp.		23,863	108	12,929	122	8,361	8,708			2,979	84½	4.34	2.81	3.75	78	68			109,072	23,788	9,918	33,580	22,003	20,301
*Macmillan Petroleum	32	14,006	85	32	[9]	128	127	1,352	1,550	1,040	11	.03			267		1,661		11,550	5,958	530			
*Maracaibo Oil		1,924	98	386	90	305	385			495	10¼	.78	.62	.30					1,841	1,255	232		124	
Mid-Continent Pet.	42	164,250	94	13,468	94	20,589	23,242	17,628	13,422	1,868	100½	7.21	11.02	4.00	3,343	3,371	15,813[3]	15,982[3]	4,242	(200)	641		718	
*Middle States Pet.	25	10,980	96	2,164	85	834	851			2,317	14⅛	.93	.36	.50†					94,658	65,995	9,033	17,075	17,953	
Mid-West Refineries[4]	21	13,094	95	385	128	487	461			648	4	.55	.75	stock					33,672	2,542	2,540	6,400	5,200	
*Ohio Oil Co.	67	250,755	103	38,224	88	16,647	24,108	23,132	32,912	6,563	68⅝	5.82	2.54	3.00	213				3,608	1,316	290	432	329	
*Pacific Western	26	14,622	110	12,518	107	2,322			2,663	5,237	43¼	2.29	.44	stock	6,449	6,262	35,508	33,634	208,318	68,592	18,731	47,399	41,365	36,000
Panhandle Oil Corp.	39	12,848	98	960	90	396	641	2,900	5,000	1,593	10⅞	.60	.25	.30					45,261	20,719	3,545			
*Phillips Petroleum	37	796,130	104	76,235	99	36,297	39,384	79,860	82,367	14,653	75	5.20	2.48	2.60	305	280	1,535	1,600	10,908	3,155	1,110	650	1,400	1,500
Plymouth Oil Co.	31	91,753	95	6,759	84	3,408	5,159		6,628	2,429	32⅜	2.78	1.40	1.94	23,848	22,693	145,292	133,043	1,092,745	150,689	93,505	169,617	140,120	higher
Pure Oil Co.	41	388,278	106	31,163	115	13,876	20,762	79,262	31,084	4,069	73	7.12	3.41	3.00	1,205	1,212			49,227	19,706	6,858	11,522	9,416	
Quaker State	25	45,744	94	2,113	101	2,804	2,521	4,800	5,242	825	27⅛	2.56	3.40	2.00	12,173	11,662	58,779[3]	55,760[2]	267,135	89,079	23,858	43,000	52,000	41,000
*Richfield Oil	43	223,311	110	25,571	89	20,241	23,783	46,759		4,000	72⅞	6.39	5.06	3.50	1,661	1,850	6,959	7,427	14,217	8,058	2,001	2,272	3,035	
*Seaboard Oil	36	39,399	103	7,470	114					3,733	45	2.04		.90	5,520	5,200	32,000	28,650	179,523	76,512	20,634	62,951	42,812	
Shamrock Oil & Gas.	26	38,175	113	7,408	130	4,329	3,184		4,598	1,502	41¼	4.93	2.88	2.40	670	580			35,502	14,346	12,555			
*Shell Oil Co.	42	1,312,060	103	121,127	105	100,995	102,112	210,028	18,669	27,480	61¾	4.41	3.67	1.87½	838	767			44,665	6,421	3,259	8,687	11,141	
*Signal Oil & Gas	32	53,918	109	9,131	101	3,652	4,804	5,665	2,500	3,737	34	2.49	.98	.70†	35,275	34,660	231,608	217,705	642,256	178,580	155,228	237,712	236,940	
*Sinclair Oil Corp.	39	1,021,461	109	74,623	110	51,157	42,872	172,000	101,285	12,350	51¾	6.04	4.14	2.60	794	682	4,688	4,309	64,792	9,666	4,743		26,836	16,400
Skelly Oil Co.	35	211,082	98	29,455	94	12,847	16,746	21,160	5,081	5,746	54⅞	5.12	2.23	1.70	23,746	23,377	130,916	126,030	1,186,771	244,420	60,777	146,879	131,765	140,000
*Socony-Vacuum	89	1,703,575	102	183,806	98	103,454	104,986		174,627	34,982	54⅜	5.25	2.96	2.25	4,754	4,725	23,856	22,796	61,388	44,423	25,868	41,755	44,626	42,000
South Penn Oil	65	52,616	90	5,057	81	4,582	4,851	4,449	9,526	1,609	32¼	3.14	2.85	2.25	38,000		247,000		1,172,284	422,709	152,675	225,240	505,000	
*Southern Prod.	12	22,847	114	4,174	156	1,237	1,423		8,965	1,727	32½	2.42	.75	1.00	2,456	2,597	11,438	11,701	24,173	23,396	3,642	5,950	2,441	
*Standard of Calif.	76	1,228,995	106	211,872	112	101,518	106,324	158,399	114,607	30,107	77	7.04	3.37	3.00†	423				54,728	6,803	4,537		8,688	
*Standard (Indiana)	66	1,677,000	97	117,160	94	74,024	94,729	264,952	122,100	32,467	48⅛	3.73	2.28	2.08†	35,354	34,940	189,811	183,859	1,386,403	282,224	118,768	223,602	281,444	300,000
*Standard (N. Jersey)	73	5,805,723	103	584,793	101	432,900	484,900	430,100	297,000	65,435	110⅝	9.56	6.62	4.55	51,270	50,870	323,089	313,594	1,574,000	409,590	123,131	209,157	284,311	200,000[12]
*Standard (Ohio)	85	374,517	97	18,527	87	17,443	18,057	58,464	33,206	4,011	45	4.41	4.35	2.40	155,000	156,000	803,900	778,600	3,574,892	1,522,006	304,003	508,700	764,000	higher
*Sun Oil Co.	54	659,532	98	40,344	89	30,171	36,278	121,483	18,742	9,662	70	4.17	3.12	1.00	11,155	11,136	60,530	59,923	178,510	69,330	22,633	37,010	37,586	48,000
*Sunray Oil	34	125,239	94	23,200	84	15,442	15,685		71,872	10,499	23⅞	2.10	1.47	1.20	21,097	24,856	117,720	131,685	342,246	81,074	70,020	129,300	93,700	75,600
*Superior Oil	34	77,421	106	10,360	86	5,108	4,394		1,175	422	751	24.54	12.10	2.00	2,133	2,184			230,446	51,039	27,873	33,495	27,848	
*Texas Co.	53	1,695,795	104	226,141	117	91,268	101,210	294,683		27,439	86	8.24	3.33	3.75	2,920	2,824			99,760	22,532	28,965			
*Texas Gulf Prod.	24	13,327	115	5,246	124	976	1,098			1,222	97⅞	4.29	.80	1.55	41,630	41,320	232,990	226,550	1,945,509	474,194	160,988	229,957	291,541	
*Texas Pacific C. & O.	66	21,876	102	7,856	103	1,954	2,751			1,772	48	4.43	1.10	1.65	196	187	1,336	1,188	25,516	4,000	2,369	5,447	7,559	
*Tide Water Assoc.	76	459,030	97	34,547	93	17,456	19,980	60,283	17,576	10,938	25⅝	3.13	1.60	.25†	454	408	52,378[3]		41,745	6,085	4,065	7,878	11,091	
Toklan	15	1,232	106	279	115	69	85	27,663	4,457	865	5	.32	.08	.16	9,338	10,494		58,914[3]	229,958	94,503	36,288	48,281	61,013	127,000
*Union Oil of Calif.	65	351,722	108	35,888	94	16,825	21,822	60,406	44,371	6,659	56¼	5.26	2.53	2.20	46	41	207	177	2,553	1,081	309	692	418	400
*Union Sulphur & Oil.	60	20,534	94	1,524	75					896	55	1.70		1.40	9,491	9,263	59,078	55,564	358,836	80,408	33,677	71,587	91,702	88,000
Universal Consolidtd.	32	5,334	101	1,631	74	850	959		2,140	639	69	2.55	1.33	2.50					26,856	14,471	4,072	9,096	6,631	
Utah Southern		2,726	112	1,010	114		355			600	19	1.68		.70	112	111	643	645	25,002	8,141	1,401	436	626[5]	600
Warren Petroleum[4]		112,406	97	8,930	87	3,393	6,564			1,700	50¾	5.25	2.00	1.70					1,392		86,871	463	604	
White Eagle Oil[14]	35	9,106	96	177	17					1,232	12	.14		.19†	2,157	1,949	10,943	9,310	99,903	6,282	9,198	14,463	22,570	
Wilcox Oil Co.	37	9,697	113	647	70	228	349		1,709	281	23⅞	2.30	.81	1.00	449	495			7,784	3,943	1,885	3,000		
*Woodley Petroleum	32	3,352	117	719	176	232	196		1,116	667	42¼	.89	.35	.50	217	226	1,006	996	8,507	1,939	443	920	714	
															75	79	460	433	10,167	1,345	459	2,682	2,682	

increase in chemical sales, and to rise in volume for those in foreign operations.

Net income did not quite reach the 1953 total, running about 2 per cent lower. Without the lower direct taxes which took effect in 1954, the net income would have dropped another 2 per cent. A number of companies had lower taxes to thank for small increases in net income.

Jersey Standard, Shell, Continental, Pure, Lion, Signal, and Texas Pacific are among those whose net increase would not have been possible without lower direct taxes for the year. Overall cut in taxes amounted to 9 per cent although some companies were paying higher direct taxes and taxes collected for local, state and federal agencies were usually higher.

Mid-West Refineries ran counter to the trend—had a lower gross income and higher net, which were accounted for by "(a) increased efficiency of our operations, (b) substantial savings in Federal income taxes effected through revision of depreciation bases and rates in addition to larger allowances from Certificates of Necessity, and (c) reduced charges for amortization of emergency facilities."

CAUSES OF DROP

Principal factors adversely affecting net income, according to the Ohio Oil Company report, were "lower crude oil production, higher depreciation and depletion charges, sharply increased exploration costs, and narrower profit margins in the company's refining, marketing and transportation operations."

Lower profit margins, the report states, resulted from more intense competition and reflect the substantial increase in the industry's capacity to produce, refine, and transport petroleum.

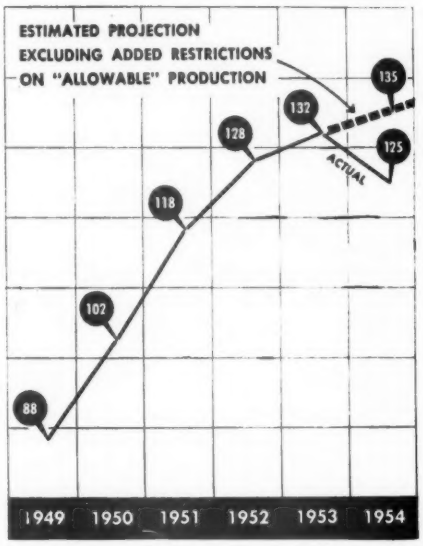
Houston Oil Company of Texas named lower production as cause of lower net income. Along with other operators the company "was allowed to produce its wells only 194 days during 1954, just over half the calendar days. This was an 18 per cent reduction from 1953's already low level of 236 days.

Footnotes to Table 1.

* Has foreign operations.
† Plus stock.
[1] Including property sales.
[2] This is first year of Delhi-Taylor merger; no comparable figures in 1953.
[3] Payroll only.
[4] Year ending June 30, 1954.
[5] Excludes intangibles.
[6] Includes foreign.
[7] Includes nonconsolidated subsidiaries.
[8] Excludes nonconsolidated subsidiaries.
[9] Loss of 270,950 in 1953.
[10] Western Hemisphere.
[11] Does not include payroll taxes.
[12] Capital expenditures expected to run between $200 and $240 million annually for next few years.
[13] Change due to abnormal dividends in 1953 from affiliated companies operating tideland properties.
[14] Year ending September 30, 1954.

A lumbering "marsh buggy" speeds up the search for oil in Louisiana. Ohio Oil Company report.

Domestic Production of
Crude Oil and Natural Gas Liquids
FIVE YEAR PROGRAM • AUGUST 1949 TO AUGUST 1954
Production shown in 1000 B/D



Sinclair showed low allowable by graph.

By participation in the drilling of 94 new oil wells (in which the sum of the company's whole or part interest totaled 59 wells) production was maintained almost equal to last year's — 14,287 bbl per day as compared with 14,406. This means, of course, that the company's capacity to produce rose substantially. But since it was allowed to produce only about the same volume of oil from a greater number of wells, the result was higher per-barrel lifting costs, less revenue per well, and lower net income."

It was pointed out in the Standard of Indiana report that Texas' 194 producing days was a decrease of 30 per cent from 1951. "During that period we added 664 new producing wells in Texas at a cost of tens of millions of dollars, and substantially increased our proven reserves in that state. But our allowable production of Texas crude dropped from 162,000 bbl a day in 1951 to 141,000, a decrease of 13 per cent!

"To illustrate the problem another way: In 1948 our wells in Texas produced 155,000 bbl a day of crude oil operating at about their maximum efficient rate; by the end of 1954, our maximum efficient rate was up to about 220,000 bbl a day, but our allowed production for the year averaged only 141,000."

The Argo Oil Corporation report stated, "Production of crude oil in the United States for 1954 reflects a decrease over the previous year for the first time since 1949. Excessive inventories of both crude oil and products, together with increased imports of foreign crude oil were the factors responsible for this decline."

Ashland Oil and Refining agreed with Ohio on narrower profit margins. "Oil refiners have been caught in a 'squeeze' between a keenly competitive, free, wholesale market for refined products and stabilized prices for crude oil which have been maintained only through severe proration of production in some important oil producing states.

"The maintenance of crude oil prices by restriction of production is not new. It has been practiced in varying degrees for more than 20 years."

But the Ashland report goes on to say: "Uneconomic relationships between the price of crude oil and the prices of refined products have always corrected themselves. Corrective factors are beginning to appear in the present situation—even though they may operate slowly. As an increasingly large percentage of potential crude oil production is being shut in by severe

Surveying is one of the first done in exploration operations, which now accounts for exceptionally high expenditures. Husky annual report.

Helicopters are used over rugged terrain in Canada by exploratory parties operating in otherwise inaccessible locations. Gulf annual report.

proration, the profits of domestic oil producers are impaired. Political pressure is building up against the importation of so much foreign oil with growing agitation for either import quotas or the levying of increased import taxes."

Cities Service supported the profit margin cause of net income decline: "Product prices reached their lowest point in mid-summer, and in many areas the profit margin on refining and marketing operations practically vanished. Competition for available markets brought destructive price wars in numerous localities."

Increased exploratory expenditure was mentioned in many reports. General American showed where it turned profit downward: "The company spent $1,680,482 on dry holes, abandonments and rentals, an increase of $1,097,039 when compared with the $583,443 spent under this category during the preceding year. If it had not been for this increase, operating income would have been substantially the same as for the prior year, despite the severe curtailment of production by regulatory bodies. If a company is to continue as a going concern, it must replace the oil produced by it either by acquisitions or discoveries, or both."

Other causes of a fairly static demand were mentioned in White Eagle Oil Company's report. Besides imports and general economic adjustments, "four winters in succession have been milder than the historical average" and "natural gas continues to increase its share of the heating market," the report stated.

Warren Petroleum pin-pointed the situation to price. " In line with, and principally as a result of, the over-all excess of supply of all petroleum products during the year, the price levels of natural gasoline and liquefied petroleum gas were somewhat below the price levels for the previous year. Field contract prices for liquefied petroleum gas were 3 to 4 cents as compared with 4 to 4½ cents for the previous year, and natural gasoline prices were 3½ to 6⅜ cents as compared with 5 to 6⅞ cents for the previous year," read the Warren report.

Among other causes, South Penn Oil Company mentions "changes in military requirements" and "drought and other adverse weather conditions."

HIGHER INCOME

There were explanations for increased income also. Texas Pacific Coal and Oil Company reported that "Despite this mandatory reduction of production, the company was able to go to market with substantially the same amount of crude oil as it did in 1953, due to newly developed reserves drilled during the year."

A small company, which did well, had this to say: "Demand for petroleum products sustained domestic crude production at a high level during 1954, setting records in the industry exceeded only by those of the previous year. For Bishop Oil Company a small overall decline in production was more than balanced by higher average prices received."

Signal Oil and Gas Company's increase was due primarily to completion in 1954 of two new gasoline plants that approximately doubled the company's previous production rate of natural gasoline and liquefied petroleum gases.

PEOPLE

Total employment remained steady despite lower net returns. There was even a slight increase in personnel, less than one per cent. It was noticeable that the companies whose income compared least favorably with 1953 usually showed a decline in number of employees.

In some cases changes had specific causes. For instance, Union Oil Company's drop was mainly due to the fact that United Geophysical Companies are no longer affiliated.

Salaries and benefits went up approximately 3 per cent in 1954 over 1953. An effort was made to determine an average of capital investment per employee but there seems to be no exact standard for estimating this figure.

PROBLEMS

The annual report is the most important communication between company management and stockholders and usually it reflects faithfully the year's events as well as the financial and operational description of the company.

Not only does management report on the activities of the company itself but it takes this occasion to explain the problems which the industry and company must meet and the results that would be profitable for the stockholders.

In the last two or three years the big problem as seen by the majority of companies was imports.

NATURAL GAS CONTROL

This year, although still in the forefront, the imports question is overshadowed by what petroleum companies believe to be a more vital problem—Federal Power Commission control of gas sales in interstate commerce. The plea to shareholders to understand the industry's position came from all types of companies.

"The most significant development in 1954, with grave implications for the entire oil and gas industry," reported Seaboard Oil Company, "was the United States Supreme Court's decision which, in effect, placed the regulation of the production, gathering and processing of natural gas in the

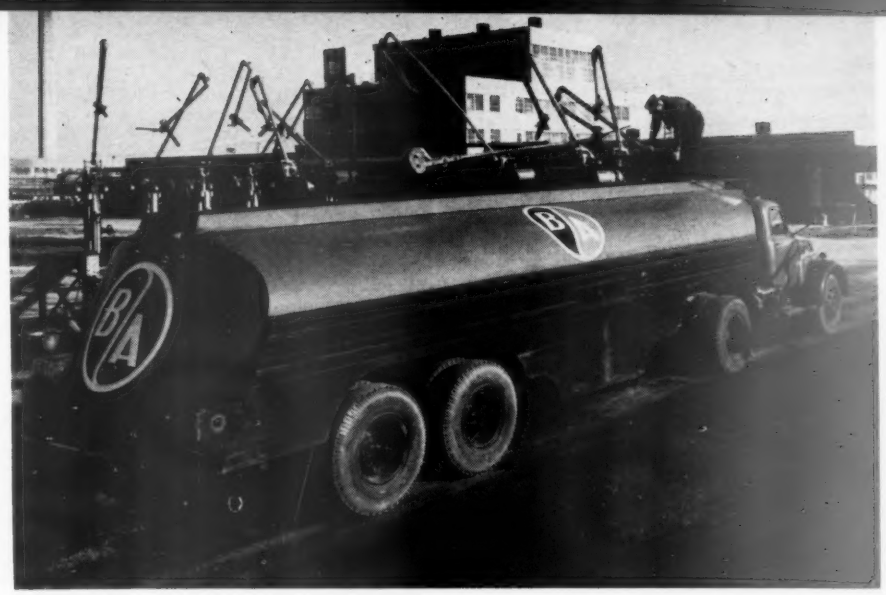
hands of the Federal Power Commission. Since gas is usually produced with oil, the control of gas operations opens the possibility that the production of oil, and indeed of all other natural resources, may likewise be controlled. The decision thus strikes directly at the vital principal of free enterprise, and only Congressional action can provide adequate relief."

Cities Service carried a warning: "In the months since that decision (Phillips case) development of gas producing properties and transportation facilities has slowed down. Many of the thousands of gas producers are hesitating to conclude sales agreements which would render them subject to Federal controls.

"More than 24,000,000 American customers now supplied with natural gas have an aggregate investment of several billion dollars in natural gas burning appliances. Their best interest, and the public interest, calls for the assurance of long-term adequacy and continuity of supplies of natural gas at reasonable rates. The inevitable result of Federal price fixing, in the years ahead, would be diminishing supplies and much higher prices for the reduced volume of gas available."

Among six principal points listed in the Deep Rock report was this statement: "Federal control can curtail exploration, deplete reserves and inevitably diminish supplies. Unwillingness of producers to dedicate reserves will make impossible the financing of new cross-country gas pipelines to serve the consuming public."

"If adequate supplies of natural gas are to be made available," Pure Oil Company reported, "producers must be compensated for the great risks of exploration as well as the high development costs. They must have valid contracts, the terms of which are not subject to change by a commission. Only on this basis can funds be obtained to provide adequate supplies and transportation facilities."



A 5000-gallon tankwagon loads with products for prompt delivery to British American branches. Distribution facilities take a big cut of capital expenditures.

Shamrock Oil and Gas Corporation is disturbed by the "confusion and uncertainty as to the extent jurisdiction can be exercised by the Commission over independent producers and the manner in which such jurisdiction may be exercised. Litigation is now pending by others seeking to clarify some of the issues involved. It is hoped that the Congress will enact legislation to clarify the situation which will leave to the states power and authority to regulate the conservation, production, gathering and processing of gas. These powers have long been recognized to be proper functions of the states."

In no uncertain terms Union Sulphur and Oil informs its shareholders: "Unless legislation before Congress removes the authority of the Commission to regulate prices of independent gas producers future revenues from gas will be influenced by the Commission's policies.

"The company's price of approximately 9 cents per thousand cubic feet of gas, currently received under contracts made several years ago, is lower than prices paid under later contracts in the company's area. The more recent contract prices in South Louisiana for large reserves have ranged from 16 cents to 20 cents."

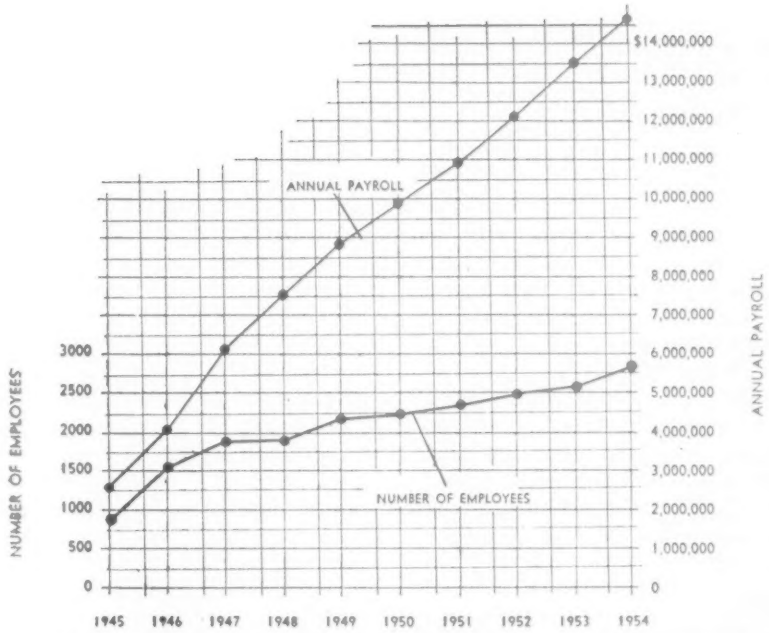
In the opinion of Tide Water Associated Oil Company, "It is apparent that price control of natural gas will remain in effect unless Congress passes corrective legislation.

"The nation's large reserves of natural gas have been developed under the basic American philosophy of free enterprise. We therefore believe that it is in your interest and the national interest to avoid the deterrent of governmental controls."

The Sun Oil Company report called "utility control harmful."

"Your company in recent years has developed extensive natural gas reserves and has invested substantial sums in processing plants. The return on these undertakings would be greatly restricted if they were to be subjected to the usual types of utility rate control.

"Of even greater importance is the threat that Federal utility regulations of natural gas production may become the opening wedge for similar control of oil production. Both natural gas and crude oil are petroleum. Federal regulation of one may be made the excuse for Federal control of the other. Should



Lion Oil Company report shows graphically the steady rise in employment and the dramatic rise in payroll over a period of nine years.

TABLE 2. OIL AND GAS OPERATIONS IN 1954

Company	Net lease or fee dev. or undev. (1000 acres)	Net wells drilled 1954	Net oil and gas producers	Net wildcats	Net discoveries	Net producing wells owned	Crude and LPG production net bbl per day	Gas production MMCF per day	Crude runs to refinery net bbl per day	Est. reserves: Million bbl oil	Est. reserves: Billion cu ft gas
*Amerada Pet. Corp.	7,788[1]	379[1]	290[1]			2,789	74,187				
*Anderson-Prichard Oil	573	80	61			1,057[1]	11,066		23,316		
Argo Oil Corp.	505	50	34			252	8,499			90	160
*Ashland Oil & Ref. Co.[2]	800	68	33	19	3	2,750	7,942		108,718		
*Atlantic Refining Co.	4,868	255	166			3,709	100,620		181,265	484	2,210
*Bishop Oil Co.	72					294	2,045			8.5	
*British-American Oil Co.		324[1]	173[1]			2,573[1]	25,433	35[3]	89,057	114	425
*Cities Service Co.	8,978	346[3]	324[3]				101,512	648	243,545		
*Continental Oil Co.	9,003[3]	505	393	102	22	5,939	131,229[4]	365[5]	126,314		2,200[6]
Cosden Petroleum Corp.	96	61[1]	38[1]			149	2,373		21,394	17	
*Deep Rock Oil Corp.	499	74	48			103	6,244	3	17,900		
*Delhi-Taylor Oil Corp.		73	63			727[1]	3,537	69	27,706		
*Douglas Oil Co. of Calif.	22	2	0			41	2,209		14,337	2	
*Drilling & Exploration Co.	257[1]	53	37			391	4,663				
*General American Oil Co.						1,207	13,022			90	
*Gulf Oil Corp.	13,976[15]	1515[1]	1250[1]	173[1]	63[1]		763,222		536,679	[16]	
*Hancock Oil Co.	2,095	66	56						12,700		
Honolulu Oil Corp.	1,617	110	82	9	1	1,088	28,500	49[1]			
Houston Oil Co. of Texas	1,537[1]	81	66	25[1]	6[1]	926[1]	14,287	59			
*Husky Oil Co.	381	161	109			196	5,302		4,234		
*Kerr-McGee Oil Ind.[7]	3,295	96[1]	70[1]			1,112[1]			7,172		
Lion Oil Co.	1,523	127	94	22	6	937	21,807	40	24,255		
Louisiana Land & Explor.	869	165[1]	132[1]	29[1]	13[1]	689[1]	17,834	23			
Macmillan Pet.	10	8	2	7[1]	1[1]	23	539		8,493		
*Maracaibo Oil Expl. Co.							1,110		2,351		
Mid-Continent Pet.[8]	1,703	208[1]	152			2,431	16,847		57,093		
*Middle States Petroleum	2,619		67			822	8,967	50		38	276
Midwest Refineries[4]									7,322		
*Ohio Oil Co.	3,359[3]	486	336	123	13	7,305[3]	93,578	209	37,286	681	2,110
*Pacific Western	443	40	31			583	18,444				
*Panhandle Oil Corp.	90	42[1]	26[1]	19[1]	7[1]	433	3,258	11	5,800		
*Phillips Petroleum Co.	11,000	406[3]	349[3]	43[3]	13[3]	14,998[1]	189,500	2260	200,000[3]		13,200[6]
*Plymouth Oil Co.	770[1]	102[1]	74[1]			1,123	17,392	84	37,750		3,700[6]
Pure Oil Co.	3,608	279	230	30	7	5,456	65,680	221	124,014		
Quaker State Oil Ref.		75	71				2,290		7,812		
*Richfield Oil Corp.			40			1,240	57,000		112,700		
*Seaboard Oil Co.		121	89				34,346	90[5]			
Shamrock Oil & Gas Corp.	609	112	100	8	1		13,310	206			1,700[6]
*Shell Oil Co.	22,101	996[1]	771[1]	211[1]	51[1]	13,715[1]	268,000	931	431,000	1250	
*Signal Oil & Gas Co.	759	101	98	26	9	958	44,610	17			
*Sinclair Oil Corp.	10,564[14]	558	470	64[3]	17[3]		144,886	282	413,701	680	1,700
Skelly Oil Co.	4,010	385	318	29	9	4,233	61,081	320	45,903		2,300[6]
*Socony-Vacuum Oil Co.		848	707	85[3]	25[3]		449,500	795	641,719	1630[3]	8,000[3]
South Penn Oil Co.	663	38	24			13,700[17]	10,124		8,997	37	65
Southern Production Co.	704	44	29			661	11,068	156		62	1,165
*Standard Oil of Calif.	34,295[11]	672	528	91	19	8,288	296,498[12]	405	431,779[12]		
Standard Oil Co. (Ind.)	15,181	747	579	150	43	11,527	249,600	990	579,500	2061	11,380
*Standard Oil Co. (N.J.)		1815	1370	392	121	25,622	1,651,000[13]		1,997,000		
*Standard Oil Co. (Ohio)	2,172	97	60	35	4	1,967	32,192	108	121,014		
*Sun Oil Co.	12,101	513[1]	322[1]	240	91	4,467	110,821	436	235,000	755	3,900
*Sunray Oil Corp.	3,092	181	128			3,463	63,312		36,979		1,500[6]
*Superior Oil Co.		247	190				60,000	177			
*Texas Co.	18,863	1446[10]	1231[10]				805,586[1]	669	798,886	2500	10,500[6]
*Texas Gulf Producing Co.	254[3]	77[1]	56[1]				10,960	375			
*Texas Pacific Coal & Oil	1,045	106	78	25	5	19,313					
*Tide Water Associated	2,322	182	133	42	6	5155	96,527	229[5]	174,983	554	2,180
Toklan Oil Corp.	77	12	11	1	1	76	1061	4		3	20
*Union Oil Co. of Calif.	4,020	302	193	122		3,310	108,748	166	146,719	538	1,864
*Union Sulphur & Oil Corp.	1,214	27	15				10,729	91			
Universal Consolidated	40	8	5	3	1	266	5,113	3			
Utah Southern Oil Co.	250						3,070				
Warren Petroleum[7]	1,228	117	94				14,054	51			
White Eagle Oil Co.	197			30	7	743	2,937	17			
Wilcox Oil Co.	114	32[1]	11[1]	17[1]		357	2,414		4,690		
*Woodley Petroleum Co.	547	141[1]	98[1]	26[1]	2[1]	376[1]	3,194	3			

* Has foreign operations. [1] Gross. [2] Report for year ended Sept. 30. [3] U. S. only. [4] Crude oil only.
[5] Gas sales. [6] FPC estimate. [7] Report for year ended June 30. [8] Now merged with Sunray.
[9] Plus working interest in 7051 producers. [10] Western Hemisphere. [11] Parent company and wholly owned subsidiaries.
[12] Excludes 325,573 B/D gross production and 121,626 B/D refinery runs represented by company's interest in Eastern Hemisphere. [13] Excludes LPG. [14] U. S. and Canada. [15] U. S. undeveloped.
[16] Report states reserves were increased last year in U. S. (slightly) and in Canada, Venezuela, and Kuwait.
[17] Does not include 8393 intake, pressure and inactive wells.
[18] Company's equity after deducting royalty and others' interests.

that possibility materialize it would end the competitive, dynamic nature of the oil business which has always served the nation so well."

Standard of California objects to the principle of control: "Regulation of such a highly competitive and risk-taking activity as the finding and producing of natural gas strikes at the basic philosophy of our country's economic system. If natural gas can be controlled today, oil and all other commodities moving in interstate commerce can be similarly controlled tomorrow. Shareholders are urged to support legislation in the United States Congress to restore the historic status of the production of natural gas."

The confusion mentioned by Shamrock may well become greater instead of less without early clarification. Continued controls may lead to sales of gas properties.

Phillips reported one large transaction this year: "In June, the Federal Power Commission granted a gas transmission company a certificate to construct and operate a natural gas pipe line extending from the San Juan Basin of northwestern New Mexico and southwestern Colorado to the states of Washington and Oregon. The company has contracted with this pipe line for the transfer of gas and oil rights to the base of the Mesaverde formation underlying approximately 200,000 acres of leases in the San Juan Basin. Gas rights to be transferred are restricted to a maximum of three trillion cubic feet. The gas transmission company will develop and operate these properties, and the company, as the gas and oil are produced, is to receive payments which increase periodically over the producing life of the properties. The company also is to be paid for wells which it has drilled at agreed prices per well."

IMPORTS PROBLEM

There is not the unanimity of opinion on imports that was held on FPC control. Strong partisan ideas are expressed on both sides. Some companies with domestic production only, which had felt the pinch of proration, want Congressional action to limit imports. Others want "voluntary reduction." The majority of reports came out with definite ideas about how to handle imports.

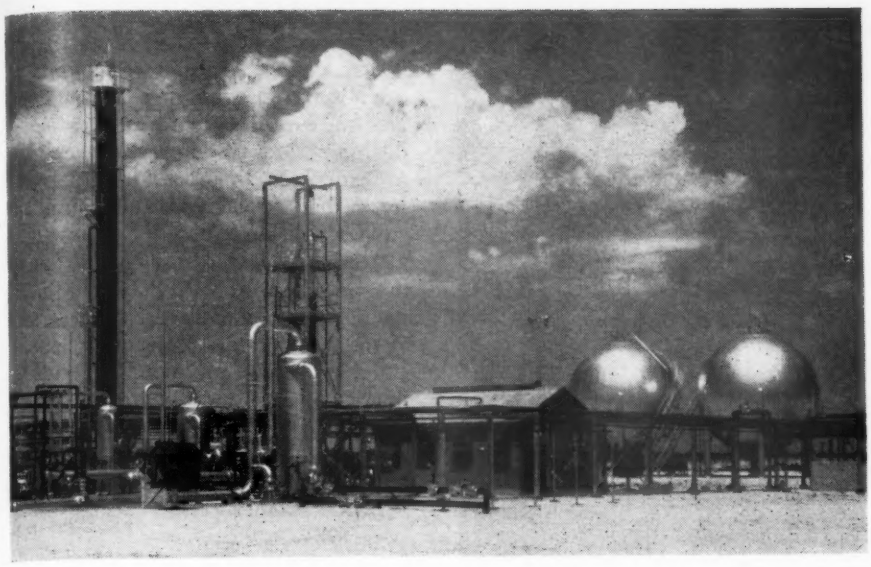
Plymouth Oil Company report calls for "some reasonable limitation."

"While indications are that the demand for petroleum will increase 4 to 5 per cent during 1955, that increase in demand would be more than offset by the pace of increased imports that has been indicated for the first two months of 1955.

"The necessity for a cut-back in imports to a reasonable percentage of domestic demand, is very apparent to any impartial mind. Certainly the time has come when domestic oil producers must take a militant position in protecting our home market from further loss. The threat to the small independent producer—who has blazed the trail in finding new oil reserves—is very real. It must be met vigorously if our domestic industry is to remain healthy and strong."

States Wilcox Oil Company: "It is increasingly hard for the small independent company to compete with cheap foreign crude oil and the Department of the Interior has, just recently, requested the National Petroleum Council to make a report on the effect of petroleum imports on the industry and on National security."

To Amerada it is the duty of the importing companies to change the trend. Its report reads: "The steadily increasing imports of foreign oil present a serious problem for the domestic petroleum industry. Oil imports within proper limits are beneficial to the American economy, and within the continued increase in American consumption there should be room for both larger domestic production and higher imports. Lately, however, imports have been increasing at a dispro-



Atlantic report shows West Texas plant where its method of increasing recovery of petroleum by high pressure gas injection is used. Secondary recovery projects are becoming routine.

portionate rate, and no reversal of this trend is in sight. It is to be hoped that the exercise of true industrial statesmanship on the part of the importing companies will bring about a correction of this situation for the benefit of all concerned."

An explanation of its own imports plan is given by Atlantic Refining Company: "A problem with which we continue to be concerned is that of imports of crude oil," reads its report. "In this connection, it might be mentioned that the crude oil which we will receive over the next few years as part payment for the Eastern Hemisphere marketing subsidiaries will not increase the proportion of imported crude which we use at our refineries. In 1954 our imports of crude as a percentage of total crude run were virtually the same as in 1953."

On the side of large importers, the Gulf report recommends: "As a result of its large developed production abroad, Gulf is an important participant in the world oil trade. Most of the company's foreign oil is marketed in foreign countries; less than one-quarter of it is imported into the United States. The company believes that over a reasonable period of time the volume of over-all imports should be related to changes in United States oil demand in such a manner that the growth in consumption is shared between supplies of domestic and foreign origin; and further, that whenever domestic demand declines, every element of supply should participate in the burden of curtailment. This type of practical and reasonable adjustment to changing conditions has taken place in the past without recourse to rigid controls, and such is believed by your management to be the best procedure for the future.

"In conformance with the import policy enunciated above, Gulf in 1954 versus 1953 increased its shipments of crude oil and products into the United States by only 2470 bbl a day, while at the same time expanding net purchases of United States crude oil by 37,486 bbl daily."

OTHER HIGHLIGHTS

Tidelands. Ownership of the "tidelands" being more or less resolved, reports now mention leasing, exploration, and drilling. Sinclair, Tidewater, and others tell of participation in the development of what may be a great new source of oil and gas supplies.

Stated the Sun report: "Realizing the potentialities of the Continental Shelf areas of Louisiana and Texas, Sun Oil Company holds offshore leases" and will "bid on future offerings."

Iran Oil. In 1951 Iran's 700,000 bbl a day oil supply was suddenly cut off by politicial expropriation and the rest of the oil word filled the void by heroic effort. In 1954 Iran's oil began coming back. Standard of California gave this review of the situation: "A group of American oil compaines acquired a 40 per cent interest in the operation of Iran's oil industry, with the company holding a one-fifth share of this interest. This action was approved and encouraged by the State Department of the United States, to restore Iran's oil production and thereby contribute to stability in the Free World. Regularly increasing demands for petroleum products are expected to permit return of Iran's oil to world markets, without disrupting the economies of other Middle Eastern countries which are primarily dependent on income from oil production."

Canadian Interests. Annual reports gave evidence of the large number of U. S. companies with properties in Canada. About two-thirds of the companies in the survey had interests abroad and nearly all of these operate in Canada.

A big event then was opportunity for Canadian gas sales. Sunray reported: "Of particular interest was the announcement in November 1954, that arrangements are now well on the way to being completed for the construction of the Westcoast Transmission Company Ltd. pipe line to the United States border, and the sale of natural gas from the Peace River area of Canada. Sunray owns an interest in Westcoast, Pacific Petroleums Ltd., and in Peace River Natural Gas Company, principal developers of the gas reserves committed to the pipe line."

Secondary Recovery. There was less mention about secondary recovery projects than in the last three years. Perhaps the volume of operations make the activities so commonplace that secondary recovery is taken for granted. Skelly Oil Company's report reviews projects in eight states and says that "the company constantly studies its producing properties for profitable use of pressure maintenance and secondary recovery methods."

Richfield goes into some detail concerning its belief in conserving oil reserves by use of the "most efficient engineering methods to the end that the greatest ultimate economic recovery be obtained from each oil and gas reservoir."

Uranium. Kerr-McGee Oil Industries was one of the first oil companies to direct some attention and effort to uranium properties. This year the company commenced "construction of a complete uranium ore concentrating plant on the Navajo Indian Reservation at Shiprock, New Mexico. This plant will operate substantially on ores produced from mines owned and operated

Income for First Quarter 1955

Company	Gross income ($1000)	Per cent of 1954	Net income ($1000)	Per cent of 1954
Ashland	60,897	98	2,095	103
Atlantic Refining	....	...	9,821	89
Cities Service	....	...	14,074	117
Continental	129,910	104	12,142	105
Cosden	12,486	110	837	110
Douglas of Calif.	5,786	99	118	85
Gulf Oil	....	...	45,320	114
Houston Oil	9,658	114	2,072	117
Lion Oil	30,499	116	5,247	151
Phillips Petroleum	212,256	107	22,110	115
Richfield	49,464	120	6,634	108
Shell Oil	354,000	107	46,285	86
Skelly			7,698	107
Socony-Vacuum			47,000	102
Standard (New Jersey)			177,000	120
Standard (Ohio)	81,000	108	6,080[1]	136
Texas Company	....	...	56,021	110
Texas Gulf	4,000	122	1,750	120
Texas Pacific	5,985	109	2,023	98
Toklan	335	113	67	92
Union of Calif.	81,799	92	7,107	84
Warren[2]	85,455	95	7,749	121
Wilcox	1,971	107	471	178

[1] Includes $879,000 property sale.
[2] 9 months ending March 31, 1955.

by the company on the Navajo Indian Reservation in the Lukachukai Mountains, some 45 miles from the plant."

Several other oil company reports refer to uranium interests.

Highways. Sun Oil's report states that another problem "affecting the oil business and the Nation's welfare is posed by the Washington proposal for a multi-billion dollar increase in Federal and state highway expenditures. More improved highways, particularly in areas adjacent to large cities, are needed. The source of revenue for such undertakings constitutes the hard core of the problem."

Depletion Allowance. Another perennial item that takes a background position this year is the depletion allowance. Only Union Oil of California goes into the question. Higher costs of finding oil makes the percentage depletion deductions more important than ever, the Union Oil report states.

"We have examined the effects of the percentage depletion on Union Oil's operations over the last ten years and found that, far from having been a 'windfall,' the capital values recovered through percentage depletion actually fell short of the net cost of our nonproductive exploration activity."

Petrochemicals. A number of companies owed the fact that their level of income was maintained to petrochemical sales. Continental stated that sales from its three petrochemical plants increased 47 per cent. Shell sales of chemical products established new records in both volume and revenue.

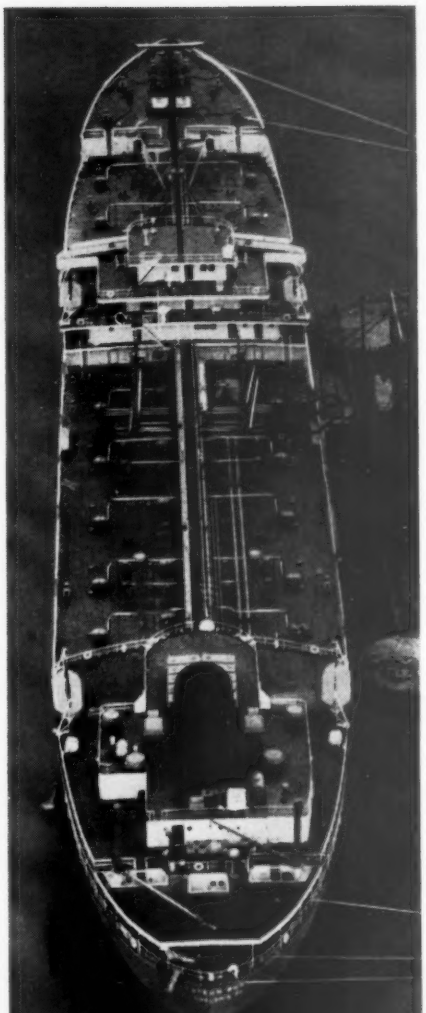
Competition became heavy with over-production although demand remained steady for some particular products.

OUTLOOK

With the weakness of the 1954 market in mind, there was some caution evidenced by companies who predicted the future but, on the whole, the view reflected the usual self-confident assurance of the whole industry.

Panhandle Oil Corporation was looking toward new possibilities because "1954 was a year in which your company made several new ventures into interesting areas and certain important exploratory deals that appear to hold promise for future profits. This expansion of activities and interests enlivened what otherwise was a year of further curtailment in domestic oil production and reduced refinery profit margins and consequent lower earnings by the company."

With a nice increase in 1954, Woodley Petroleum could report cheerfully, "The continued rise in demand for petroleum and its products signifies basic strength in the oil industry. The drilling of more than 53,000 wells last year in the United States . . . and forecasted capital expenditures . . . are impressive evidence of the good health of this dynamic industry."



S. S. Western Sun, third of four supertankers, joined Sun Oil fleet in 1954.

There is no question about one element in 1955, according to Continental. Its report states: "While the outlook concerning demand and inventories is problematical, there is this certainty: competition will intensify. Successful meeting of this competition will require still further improvements in product quality, particularly in the octane ratings of gasoline. Better service and improved facilities, combined with more effective sales effort, will also be essential."

Inventories are the problem, Cosden Petroleum believes: "National gasoline inventories are well above levels at which firm prices can be maintained. The next few months have been described as a dangerous period by some well qualified observers, but we view the future with confidence. We have so far been able to maintain a spread between crude oil price and product selling prices, that is as good as the industry average or better. Of course, we are not exempt from price fluctuations, and our earnings are adversely affected during periods of depressed prices. We are keeping our house in order and hope that other companies similarly situated will do likewise."

South Penn Oil also warns about over-production: "Producers and refiners must maintain their operations at the level of their consumers' needs, since crude oil producibility and refinery capacity have increased far in excess of indicated requirements; otherwise, excessive stocks will again plague the industry, making it essential to experience another period of adjustment as in 1954."

Late 1954 and early 1955 improved the outlook, Sinclair decided. The report read: "Toward the year end, however, a reversal of trend was definitely under way. A sharp increase in demand continues thus far into 1955, giving every promise of a year of good business to those equipped to cope with keenly competitive conditions. Inventories of petroleum products are no longer burdensome, nor need they become so if the industry gears its refined product production to a realistic and flexible appraisal of sales demand."

Texas Gulf Producing has reservations to its predictions: "The outlook for the oil industry this year in general is good, with various industry predictions showing gains in demand ranging from 3 to 5½ per cent above 1954. These predictions depend a great deal on the weather and upon the amount of imports which are brought into the country."

Standard of Ohio takes a look at both good and bad features and finds: "Many of the factors which were significant in 1954 will continue to affect operations this year. However, it appears probable that the growth in consumption will be somewhat greater than that of last year. Operating costs are unlikely to decline. The price of gasoline thus far is slightly below the average level of 1954 and unless some improvement occurs, the margin between realized prices and cost in 1955 will be the same or somewhat less than last year. Summarizing these factors, it would appear that the 1955 outlook is for a moderate improvement over 1954."

This sounds like a very safe and sane prediction for the year we are in. The first quarter reports are on the whole an improvement over the same period in 1954. The year will depend upon Congress, the weather, vacations, TV, highways, car sales, and scores of conditions and situations. * * *

Exploration, Drilling, Producing

Monterey, KCL Venture

Kern County Land Company and Monterey Oil Company are entering into a coastal exploration program in Louisiana. Both companies are better known in California, although Monterey also has been active in Texas, Louisiana, and the Rocky Mountain region. Kern County Land, one of the largest cattle operators in the west, has some 970 wells in production and has land holdings in California, New Mexico, Arizona and Oregon. The two companies are also planning exploration of a 330,000 acre block in Montana and Wyoming this year with a group of other companies.

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Rocky Mountain Field Trip

Rocky Mountain Association of Geologists has plans of making its spring field trip into the currently active Front Range of the Rockies west of Denver, Colorado. Oil was discovered in the vicinity late in 1954 beneath the Golden Thrust Fault in the Morrison area. The trip, scheduled May 20, will place emphasis on fault structures, sedimentation of Dakota and Lyons sandstones, and oil seepages.

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County Nets $3,500,000

County of Los Angeles, California, has added nearly $70,000 yearly from oil revenues from 16 oil and gas leases on county-owned property.

Since 1950 oil royalties have brought in $3,515,544 on leases on county flood control district land and the Wayside Honor Farm property which the county owns.

★ ★ ★

Argentina Exploration

Oil exploration in Argentina is expected to be placed on a new basis soon. The government of that South American country, under President Juan Peron, has indicated its willingness to grant concessions to the American companies. Those negotiating for exploration rights are said to include Standard of California, Jersey Standard and Shell.

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'Privileged' Scientists Hit

"Citizens first, scientists second," is the position assumed by the American Association of Petroleum Geologists, as expressed before the Oil Finders Convention in New York. Its committee criticized a resolution passed by the American Association for the Advancement of Science to the effect that government funds for research not involving national security should be granted to all except proven Communists, regardless of whether they are denied security clearance. The AAPG rejected such a privileged position, reprimanding those scientists who think themselves rugged individualists and place personal privilege above personal responsibility.

★ ★ ★

Hall of Oil Geology

American Museum of Natural History has now opened its Hall of Oil Geology in New York City. The exhibition, a joint effort of the Museum and Jersey Standard, is probably the largest and most complete exhibit of its kind ever constructed. On display are models of a drilling rig, three-dimensional oil-field structures, exploration tools, charts, and other items common to the oil industry. The hall was opened for research laboratory and teachings, as well as for entertainment purposes.

★ ★ ★

Indians $6,000,000 Richer

Lease sales on Indian reservations in North Dakota have made tribes $6,000,000 richer. Sold to companies were 881 separate leases covering 182,787 acres, the most of which are located in McKenzie County.

★ ★ ★

50 Billion Bbl Undiscovered

Although the United States has an established reserve of 31 to 55 billion barrels oil, there are 40 to 50 billion yet to be discovered, Society of Exploration Geophysicists President Paul Lyons stated in an address at the Oil Finders Convention in New York. Lyons also expressed his concern over current decline in exploration.

★ ★ ★

Mesa Drilling Sold

Great Basin Petroleum Company has sold its Mesa Drilling Company and equipment to Southern California Petroleum Corporation of Los Angeles. Southern California is entering into exploration activity with Great Basin in the Rocky Mountain region. Involved in the sale were Mesa's five drilling rigs now operating in that area.

Kansas Crude Runs Cut

Production in several Kansas fields will be slashed drastically by the reduction of crude purchases by White Eagle Oil Company, Inc. The Socony-Vacuum subsidiary is reducing its pipe line runs to 60 per cent of average daily purchases in November and December of last year, now taking only about 16,000 bbl daily.

★ ★ ★

New Name for AIME

Pending final clearance of charter details the AIME will henceforth be known as the American Institute of Mining, Metallurgical, and Petroleum Engineers. Addition of "Petroleum" to the name was recently approved by the directors of the organization as some 7000 members, or more than 30 per cent of the total membership, belong to the oil branch.

★ ★ ★

Railroad Gets Royalties

Northern Pacific Railway owns more oil and gas rights in the Williston Basin than any other concern, company officials have revealed. Last year the firm realized $1,327,018 from oil development on its properties.

★ ★ ★

Bureau Sets Fees

Service charges have been proposed for public land uses, mineral leases and permits issued by the Federal Bureau of Land Management. Fees will range from $2 to $15 and will bring in an estimated $235,000 yearly. Most of the services have been offered without charge.

★ ★ ★

Liquidation Stymied

North Central Texas Oil Company, which has been planning liquidation of assets for the past month, has met with an injunction by a chancellory court in Delaware on appeal of one stockholder. Approval of the sale was made effective by a vote of stockholders in April.

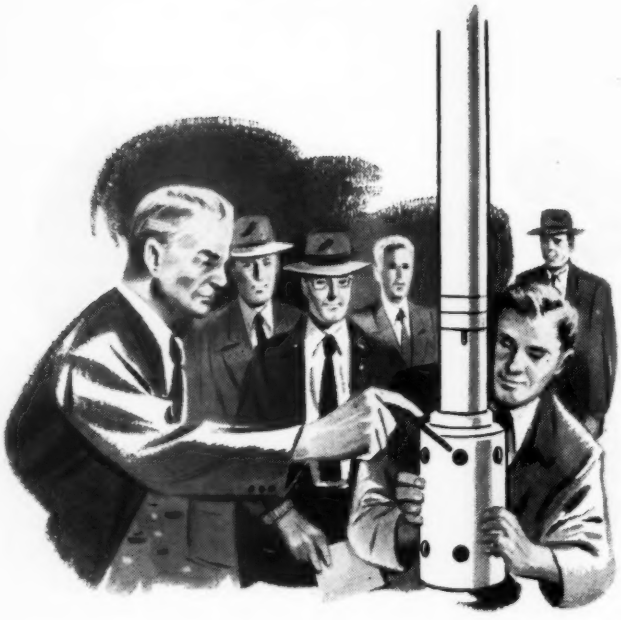
★ ★ ★

Lease Sale Hinted

Agitation for a third federal sale of offshore leases along the Gulf Coast has been revealed by the Department of Interior. Eleven oil companies have expressed interest in almost 600,000 acres of submerged lands, considerably more than was auctioned off in two sales last fall.

It takes all three

to get results—



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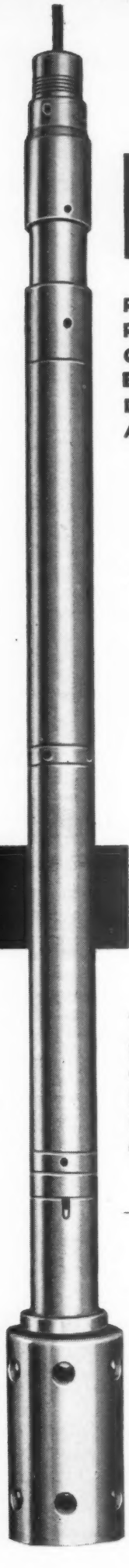

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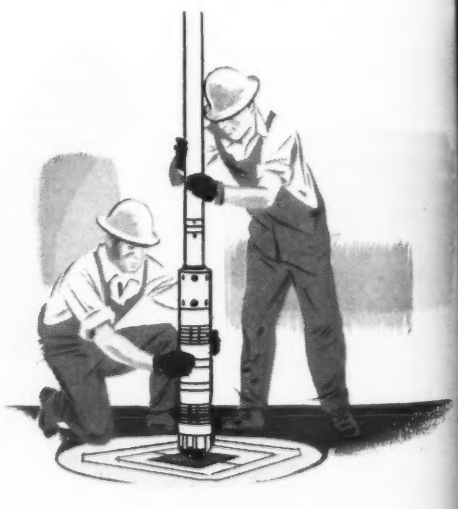

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Future Possibilities in the Appalachian Basin

Plagued from the beginning by drilling difficulties and stratigraphic barriers, this area-point of embarkation in the worldwide search for oil—remains virtually undeveloped.

Earl H. Linn

EXCLUSIVE

THE Appalachian Basin is the birthplace of a 100-year old industry, and consequently, should be the most thoroughly drilled oil basin in the industry. Surprisingly enough, very few wells have been drilled to test the Cambro-Ordovician section. You would surmise, that in an area that has produced as much oil and gas as the Appalachian Basin, all the formations would be tested thoroughly, before writing the area off as either depleted or marginal. The drilling depths to the Cambro-Ordovician are not excessive in the most likely areas. Also, the full potentialities of the shallower formations have not been explored thoroughly.

Present Exploration

Present exploration in Pennsylvania is confined primarily to Lower Devonian (Oriskany) gas prospecting in north central Pennsylvania, west of the Appalachian structural front. This prospecting is being conducted on surface structures which, when drilled, prove to be much more complex than the surface structures indicate. The Oriskany sand is erratic in thickness and in areal extent. It is not uncommon to drill a structure with thick sand but with poor porosity and permeability. It seems that the production found on structures is governed by faulting, which increases the effective porosity and permeability of the pay sand. The best wells are those that are drilled close into the fault plane.

There is an area in northwest central Pennsylvania where the Oriskany sand is shaled out. The present exploration is taking place east of this facies change, and west of the structural front. The production is governed by the combination of up dip facies changes and local structures. Oriskany production is characterized by the high initial open flows with abnormally high rock pressures. The average recovery for Oriskany sand, in this area, is between six and seven million cubic feet of gas per acre. Wells drilled close into fault planes have a higher initial open flow and a subsequent higher recovery. Fifteen to twenty million cubic feet of gas per acre is not uncommon in such areas.

Oriskany gas exploration also is being conducted in the highly faulted and folded regions in south central Pennsylvania, West Virginia, Maryland, and Virginia. These regions are located east of the Appalachian structural front. Production has been established as far east as Rockingham County, Virginia.

In this area, the gas is found on a structure that has the Oriskany outcropping approximately four miles to

the east and four miles to the west of the crest of the dome. Two wells have been completed from the Oriskany sand in Hampshire County, West Virginia. Although the open flows to date are not spectacular, they have proved that an Oriskany pool does exist in this area. One well in Hardy County, West Virginia, just south of Hampshire County, encountered a good show of gas in the Oriskany sand at a depth of less than 1000 ft. This well is located approximately ¾ of a mile west of the outcrop of the Oriskany sand, on the northern end of a very pronounced anticline. Just north of the Pennsylvania-Maryland state line in southern Bedford County, John T. Galey drilled an Oriskany well that showed 30,000 cu ft of gas per day.

In northwest Pennsylvania, the Pennsylvania Gas Company is in the process of developing its Silurian (Medina) gas pool near Corry, Pennsylvania. The production in this formation is spotty, the sands being erratic and lenticular. The average depth of the wells is 4200 ft.

Presently undergoing development and extensive drilling are the Roaring Fork and Middle Fork districts of Randolph and Upshur Counties, West Virginia, west of the Appalachian structural front. Production and prospecting here is primarily for the Upper Devonian gas sands, found at depths ranging from 1700 to 2300 ft deep.

The Maxton sand, Mississippian age, is being developed in the Glade district of Webster County, West Virginia. This area lies southwest of the Randolph and Upshur County play. Depth to the producing horizon is 1700 ft, and the open flows vary between one to three million cu ft gas per day.

Two wells of considerable importance are now being drilled. One, a proposed basement test, the first in this area, is located on the Burning Springs Anticline in Wood County, West Virginia. The other well, in southwestern New York, Chautauqua County, Harmony Township, is drilling in the Upper Cambrian. This well reported the top of the Middle Ordovician at 6124 ft (—4552). From 6880 to 6889 ft, it gaged 60 Mcf, and at 6992 ft, two bailers of salt water per hour were reported. This was probably in the Lower Ordovician section or the bottom of the Black River formation.

In southeastern Kentucky and southwestern Virginia developments and exploration are taking place adjacent to, and within the Cumberland overthrust. This exploration is aimed, primarily, for Mississippian and Siluro-Devonian gas production, with substantial reserves already having been established in Dickinson and Buckhannon counties, Virginia. No exploration has been done within the Kentucky and Tennessee portion of the Cumberland overthrust. As of this writing, the first well "between the two mountains" is drilling below 1100 ft in Bell County, Kentucky.

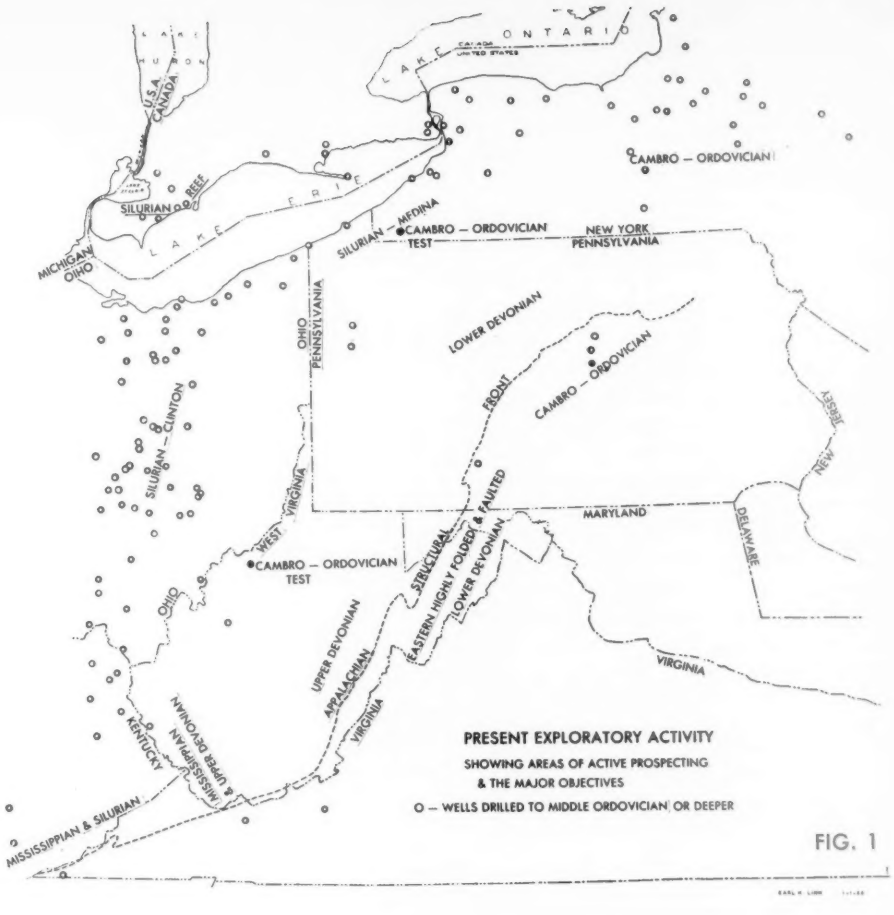


FIG. 1

In central Ohio, the drilling is confined to extending the known producing Silurian horizons (Clinton sands). This is the primary objective of most of the wells in this area. It is on a proved stratigraphic trend, and does not represent a new development.

Devonian Prospects

Upper Devonian. Outside of the areas presently undergoing development and exploration within the old proved province, there seems to be an area worthy of future testing in northeastern and south central Pennsylvania. Fig. 2 shows the restored paleogeologic conditions at the close of Chemung (Upper Devonian) time. Superimposed upon this map is the outline of the old oil and gas regions that have been producing for almost 100 years. Production has been, principally, from the Upper Devonian Series. This oil and gas belt is not solid production. The pools in these areas produce from a multiplicity of sands, all, however, being Upper Devonian in age. This productive belt represents one large stratigraphic type trap within a series of formations.

The area of maximum marine deposition appears to pass through Somerset, Cambria, Clearfield, Center, and Tioga Counties. West and east of this area, the marine section thins, with the thinning taking place more rapidly eastward, then westward. The west side of the basin is a shelf area of thinning marine deposits, while the east side is an area of thinning marine deposits, and thickening continental deposits. The rock facies changes from west to east. On the west side, where production has been found, the Upper Devonian consists of alternating sands and shales. In the center of the basin, shales, and sandy siltstones make up the marine section. On the east side, sands, shales, and sandy siltstones, again, make up the marine section.

The prospects for new Upper Devonian seem to be limited to the comparatively unexplored area in the east central section. The most likely areas for testing the potentialities of the Upper Devonian, lie adjacent to the transition area, where marine and nonmarine sediments merge.

Several wells have been drilled along this trend. One, in Lycoming County, Mill Creek Township, found 250 Mcf gas per day at 1800 ft in a 10-ft sand section, and 300 Mcf gas per day at 2000 ft in a shaley sand section. In Bedford County, Broad Top Township, Benedum-Trees No. 1 Rockhill Iron

and Coal Company had good gas shows throughout 1000 ft of Chemung section. Both of these wells logged considerable sand and sandy siltstone.

Lower Devonian. Oriskany production will probably be extended, southwest of the present producing trends in north central Pennsylvania. The limits of the new pools will be determined, largely, by the extent and development of the sand.

Probably the area with the best potential for new Oriskany production lies east of the structural front, in the highly faulted and folded areas of Pennsylvania, Maryland, West Virginia, and Virginia. This area has had very few wells drilled to the Lower Devonian. Every well that has been drilled, has had either salt water, encouraging shows, or has made a commercial well. The sand here is thicker, up to 300 ft, than it is in the west, and the structures are more pronounced and more complex. Because of this complexity, drilling is slower and more expensive. Before starting a wildcat in this section, it would be wise to shoot several seismic lines across the structures, to determine if any cross faults or reverse faults are present.

Silurian

New Silurian production in the Appalachian Basin will have to be limited to the uncovering of new stratigraphic traps, which will have to be located deeper in the Basin. Areas in northwestern Pennsylvania, southwestern New York, and northeastern Ohio, have been virtually untested for Medina production.

There is, at present, a small Medina pool in Erie County, Pennsylvania, just northwest of the town of Corry. While this pool is not extensive, nor the production prolific, it does indicate that there is a possibility of a new stratigraphic trap trend present in this area. In this northwest area, the Medina, in many instances, has carried shows of gas and salt water. Yet, wells that revealed these leads were never followed up with more drilling.

Future Medina exploration should not be considered, unless the operator is willing to set up a three or four well drilling program. The wells should be drilled one at a time, with the information gained concerning the sand's thickness, porosity, permeability, and content serving as a guide for the next test, and so on, until the acreage block is evaluated. The drilling depth is not deep, 4200 ft average, and the cost of drilling three or four wells in this area would not exceed the cost of one 7500 ft Oriskany test in central Pennsylvania.

Cambro-Ordovician

The most unexplored formation within this area is the Cambro-Ordovician. As can be seen from Fig. 3, all of the Cambro-Ordovican tests that have been drilled to date, have been located on the rim of the province, with the exception of wells No. 2, (Manufacturers Light and Heat, Hockenberry), No. 3, (United Natural Gas Company's Davidson No. 1), No. 7, (Reserve Oil Company's Mahaney No. 1), and No. 8 (New York Natural Gas Corporation's Kesselring No. 1) in New York. The main reason for the locations of these tests was because the Cambro-Ordovician formations are at a shallower depth.

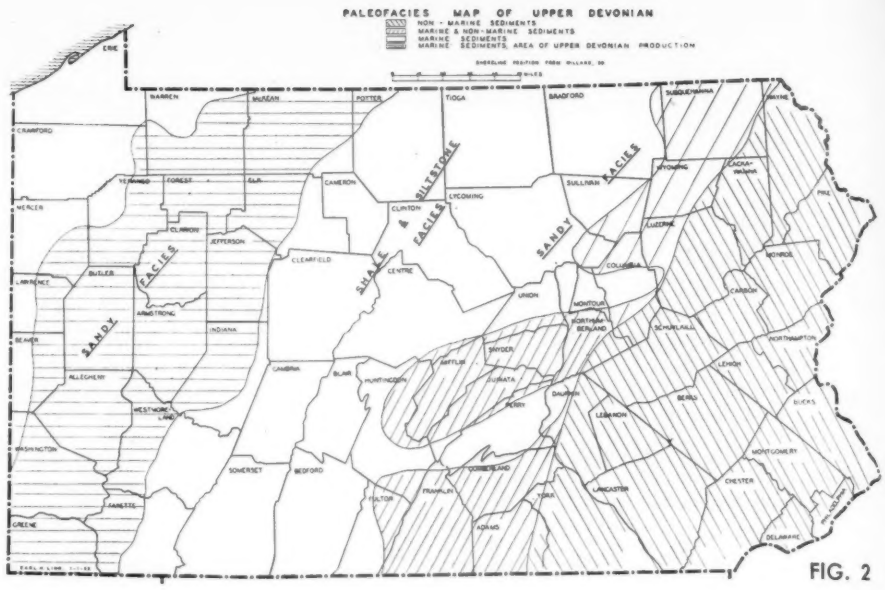


FIG. 2

Fig. 3 is a preliminary isopach map of the Beekmantown formation, Lower Ordovician, showing the locations of Middle Ordovician and Cambrian test wells. It also shows an area where the Uppermost Cambrian beds are missing. The exact position of where these formations, Lower Ordovician and Uppermost Cambrian, are truncated is unknown. In discussing the Cambro-Ordovician, the author has drawn heavily on Dr. C. R. Fettke's correlations in his sample studies of well records. The isopach of the Beekmantown in central Pennsylvania, is taken from Dr. F. M. Swartz's study.

The most widespread and significant geologic feature in the Cambro-Ordovician series, insofar as oil and gas prospecting are concerned, is the unconformity at the base of the Middle Ordovician. The Lower Ordovician is missing around the west, northwest, and north rim of the basin. Whether this is a case of erosion or nondeposition, the author does not know. It seems that the area in east central Ohio was a depositional barrier, or a positive high area during Beekmantown time. The writer agrees with Dr. Fettke that location of this positive area was east of the present Findlay Arch.

This depositional barrier, or erosional high, became more pronounced from central Ohio, northward into northeastern Ohio, and northwestern Pennsylvania, where the Uppermost Cambrian was either not deposited, or eroded away. Here, in this area marked Lower Ordovician and Upper Cambrian missing, the Black River, (Middle Ordovician), overlies the Middle Upper Cambrian.

The Lower Ordovician possibilities will be discussed first, and the Cambrian possibilities second. Wells numbered one, two, and three in northeastern Ohio, encountered no Lower Ordovician. Well No. 2, (Manufacturers Light and Heat, Hockenberry), in western Pennsylvania, cut 187 ft of Larke dolomite from 9553 ft to 9740 ft, with the top of the formation being at a subsea depth of —8247 ft. This section was barren. Well No. 3, (United Natural Gas, Davidson No. 1), in Pennsylvania, drilled approximately 65 ft of Lower Ordovician, and was bottomed out in the same, when the well was plugged and abandoned. This well found salt water in the Larke Dolomite, and found the top of the Lower Ordovician at a subsea depth of —7400 ft, or 840 ft higher than well No. 2.

The George Button well, No. 2 in New York state, found the Lower Ordovician missing. The Arcade well, No. 4, drilled 86 ft of Lower Ordovician from 6109 ft to 6195 ft. Here the formation is called Tribes Hill, and is an argillaceous, oolitic limestone, rather than a dolomite, as is present in western Pennsylvania. At a depth of 6182 ft, 73 ft from the top, this well showed 25,000 cu ft gas per day. The subsea elevation on the top of the Lower Ordovician was —4712 ft.

From these three widely spaced tests, it can be seen that the Lower Ordovician has potential reservoir possibilities

on the northwest flank of the Basin. From the meager amount of subsurface information known, it seems likely, that as you approach the northwest limit of deposition or truncation, the facies should become more sandy, due to the probability that some sedimentation was coming from a positive area to the northwest. The drilling depths in this area are not prohibitive, and the formations can be reached easily, with either cable tools or rotary tools.

The method of exploration here, again, will entail the drilling of several wells before the area can be evaluated. This objective will be deeper and more expensive than prospecting for the Silurian. If the program is a success, the operator would not only be evaluating one acreage block, but, possibly, opening up a new and more uniform stratigraphic pool—in effect, a new oil province. It is fortunate that the area most likely to be productive from the Lower Ordovician and Uppermost Cambrian, falls in the same area of potential new Silurian production.

The Lower Ordovician has been penetrated by two wells in the mountains of central Pennsylvania, No. 4 and 5, on Fig. 3. The California Company well, No. 4, had shows of gas in the Middle Cambrian, and the Deep Rock Well, No. 5, had a show of gas at 1900 ft, formation unknown. These wells were drilled on very pronounced structural domes, that in all probability, were faulted at depth. They have proved that the formations, despite being highly faulted and slightly metamorphosed, still retain some hydrocarbons.

The Mahaney well in New York, well No. 7, drilled 211 ft of Lower Ordovician, argillaceous limestone from 5887 to 6098 ft. There were no shows of oil, gas, or salt water reported. The subsea top of the Lower Ordovician was —5063 ft. The Kesselring well, No. 8, drilled 280 ft of Lower Ordovician. Here again, the formation was argillaceous limestone, with 100 ft of cherty dolomite at the base. There were no shows of either oil, gas, or salt water in this formation. The subsea top of the Lower Ordovician was —8679 ft. The Lobdell well, No. 5, encountered no Lower Ordovician.

The position and the reservoir conditions of the Ordovician within the Cumberland overthrust in southeast Kentucky, southwest Virginia, and northern Tennessee, are also unknown.

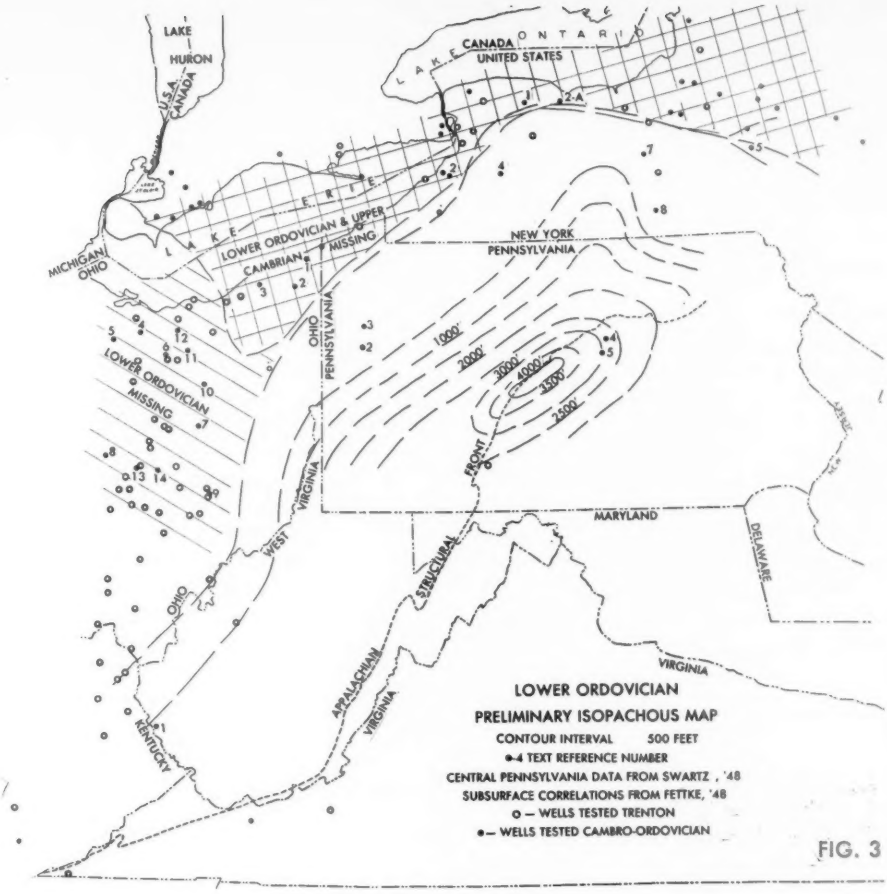


FIG. 3

TABLE 1.

No.	County	Township or district	Farm	Company	Year completed	Elevation	Top of Trenton limestone	Total depth	Oldest rocks reached
				OHIO					
1	Ashtabula	Sheffield	George W. Kelsey #1	Ohio Fuel Gas	1930	851	4932	5582	Trenton?
2	Ashtabula	Rome	George E. Chester	Ohio Fuel Gas	1930	878	5315	6004	Upper Cambrian
3	Geauga	Chardon	G. W. Crile #1	East Ohio Gas Co.	1941	1031	5260	6101	Upper Cambrian
4	Huron	Peru	B. and P. Arting #1	Clarence White	1937	749	2505	4270	Pre-Cambrian
5	Seneca	Scipio	Harry Bishop #1	Ohio Oil Co.	1942	908	2056	3123	Cambrian
6	Ashland	Ruggles	S. V. Krause	Ohio Oil Co.	1945	1114	3758	5251	Mount Simon
7	Coshocton	Clark	Chaney Meyer Unit 2	Ohio Oil Co.	1944	800?	4733	5660	Upper Cambrian
8	Delaware	Orange	Herman E. Vance	Chester L. Wise et al		920	2100	4291	Pre-Cambrian
9	Muskingum	Salt Creek	Sidney Whitemore #1	Industrial Gas Corp.	1946	827	5800	6740	Upper Cambrian
10	Wayne	Wooster	J. H. Armstrong #8	Ohio Oil Co.	1941	1119	5003	6116	Knox
11	Medina	Spencer	Clayton Billman #2	McCrea and Ditch	1939	926	4090	5071	Pre-Trenton
12	Lorain	Pittsfield	A. E. Nash #1	Hanley and Bird	1946	820	3547	4299	Pre-Trenton
13	Licking	Jersey	Bertha Rowe	S. D. and W. B. McCloy	1941	1240	3320	4370	Pre-Trenton
14	Licking	Newark	Wehrle 126 (8)	Wehrle Gas Co.	1925	865	3696	4374	Pre-Trenton
				NEW YORK					
1	Orleans	Clarendon	Henry Emilkamp	Clark Coye et al	1932	660	1972	3030	Pre-Cambrian
2	Erie	Collins	George Button			660	3835	4602	Pre-Cambrian
2A	Monroe	Rochester	"Rochester" Well		1891	506	2006	3100	Pre-Cambrian
4	Wyoming	Arcade	K. R. Wilson #1	K. R. Wilson	1946	1483	5342	7144	Potsdam
5	Chenango	Columbus	Clarence Lobdell #1	Bradley Producing Corp. et al	1949	1373	4276	5701	Pre-Cambrian
7	Cayuga	Ledyard	J. C. Mahaney #1	Reserve Oil Co.	1931	824	5054	6166	Little Falls
8	Chemung	Van Etten	E. C. Kesselring #1	New York Natural Gas Corp.	D	1077	8902	11,145	Pre-Cambrian
				PENNSYLVANIA					
1	Erie	Springfield	Jay Childs #1	Ohio Oil Co.	1941	638	4437a	5191	Gatesburg
2	Butler	Mercer	Jessie G. Hockenberry	Manufacturers Light & Heat	1944	1306	8812	10,096	Gatesburg
3	Mercer	Worth	Maude-Davidson #1	United Natural Gas Company	1945	1420	8177	8892	Beekman town
4	Lycoming	Limestone	W. G. Snyder	Snee & Eberly	1951			5808	Upper Cambrian?
5	Clinton	Green	Walizer	Deep Rock Oil	1953	1291		4533	Gatesburg
				VIRGINIA					
1	Tazewell		J. M. Hoge #1—1932	United Producing Co.	1950	3052		5632	Cambrian
				WEST VIRGINIA					
1	Wayne	Lincoln	F. D. Caldwell et al	United Fuel Gas Company	1949	688	5610?	7900	Knox
				KENTUCKY					
1	Knox		Hammonds #1	Schmidt et al		1014	undiff.	5000	Cambrian

This area has long presented a problem to structural, as well as petroleum geologists. The only way to gain any more information is to drill through the thrust sheet, and into the Cambro-Ordovician rocks.

There are many known active oil seeps on the northwest face of the thrust sheet that deserve further consideration.

Cambrian

Cambrian possibilities exist, for the most part, around the northern and northwestern rim of the Basin. Fig. 3 shows an area where the Uppermost Cambrian is missing. This area coincides with the area of Lower Ordovician hiatus. In this area, the Middle Ordovician overlies the middle section of Upper Cambrian.

Fettke reported that "...of 67 available records of wells that penetrated strata below the Black River in central Ohio, 27 reported showings of oil and gas, some accompanied by salt water a short distance below the unconformity less than 40 ft.... As most oil and gas showings reported from the Upper Cambrian rocks in central Ohio occur close to the unconformity, and as, in most instances, only salt water has been found at greater depths, it seems possible that there has been some up dip migration of oil and gas along porous and permeable members which has been trapped beneath the unconformity."

Wells No. 1, 2, and 3 in northeastern Ohio, drilled through the Black River formation into the Middle Upper Cambrian. Well No. 11, (McCrea and Ditch, Billman No. 2), in Ohio, drilled 225 ft± of Upper Cambrian, Trempealeau formation. This formation showed salt water. The subsea depth to the top of the Trempealeau was —3829 ft. Well No. 12, (Hanley and Bird, Nash No. 1) drilled about 35 ft into the Trempealeau, and found shows of gas and oil. The subsea depth to the top of the Trempealeau sandstone was —3402 ft. Well No. 6, (Ohio Oil Company's Krause No. 1), drilled 265 ft of Trempealeau formation. The top 22 ft showed 26,000 cu ft gas per day initial open flow. The subsea top was —3304 ft. There was a slight oil show at a depth of 4420 ft to 4434 ft, and salt water was encountered at 4432 ft. Well No. 4, (Clarence White, Arting No. 1), drilled 260 ft of Trempealeau with the subsea top at —2350 ft, and found a showing of oil at the top of the formation, and salt water as it was drilled deeper. Well No. 8, (Chester L. Wise et al, Herman E. Vance), drilled approximately 500 ft of Trempealeau formation. This well found the formation to be saltwater bearing.

If Fettke's subsurface correlations are correct, then from Well No. 8 to Well No. 6, there is a decrease of 225 ft of Uppermost Cambrian in a distance of 65 miles in a northeasterly direction. Also, there is a decrease of from 225 ft to 0 ft from Well No. 6 to Well No. 3, a distance of 70 miles in a northeasterly direction. This decrease in section, in a down dip direction, tends to verify a Cambrian high in the northeast area.

In northwestern Pennsylvania, the Childs Well, No. 1, drilled through the Black River formation into the Middle Upper Cambrian. The base of the Black River was found at 5179 ft (—4541 ft.) The Cambrian formation had a slight oil and gas show, and salt water. The Hockenberry well, No. 2, drilled 308 ft of Mines Dolomite, the top of the Mines, or base of the Black River, was 10,048 ft (—8434 ft). At 9746 to 9771 ft, a show of gas was found, which failed to respond to acidizing. The Mines section was very fine to crystalline Dolomite, with quartz silt, and very fine quartz grain interspersed. The Middle Upper Cambrian showed one bailer of salt water per hour at 10,192 ft.

In southwestern New York state, Well No. 2, (George Button), encountered no Little Falls Dolomite, while Well No. 4, drilled 130 ft of fine, crystalline, cherty, and sandy Dolomite.

The interesting feature about this area is the overlapping of both the Lower Ordovician and Upper Cambrian strata by the Middle Ordovician. Between the Childs well, and the Hockenberry well, in western Pennsylvania, 520 ft of section is missing. Between Well No. 2, and Well No. 4, in New York state, 216 ft of formation is missing. Although the amount of section truncated is not great, in comparison to the area involved, it is significant that where these formations were penetrated down dip, they carried shows of gas and salt water.

Well No. 8, in New York state, cut 434 ft of Little Falls Dolomite. This well was bottomed in the Theresa formation, which was found to carry considerable amounts of salt water. Well No. 5, logged no Lower Orodvician, but did log 140 ft of cherty Little Falls Dolomite. This same well also encountered considerable salt water bearing zones in the Theresa formation, immediately underlying the Little Falls Dolomite. Perhaps farther northeast, toward the Adirondack high, this Theresa formation may carry oil and gas. It is an area worthy of future study and exploration.

The Author

Earl H. Linn is an exploration geologist for the Benedum-Trees Oil Company and the Hiawatha Oil and Gas Company in Pittsburgh, Pennsylvania.

He was graduated from the University of Pittsburgh in 1949 with a BS degree in geological engineering and joined the Benedum-Trees organization as exploration geologist. He has done work in the Northern Appalachian Basin, southeastern states, West Texas, Oklahoma, Mid-Continent, and Rocky Mountains.

References

Appalachian Geological Society Bulletin, Vol. I, 1949.

American Association of Petroleum Geologists, 1948. *Appalachian Ordovician Symposium.*

Ball, Max W., 1951, "Possible Future Petroleum Provinces of North America," *Bulletin American Association of Petroleum Geologists*, Vol. 35, Part I.

Bayles, Robert E., 1949, "Subsurface Upper Devonian Section in Southwestern Pennsylvania," *American Association of Petroleum Geologists*, Vol. 33, Part II.

Fettke, C. R., 1949, "Pennsylvania," *Bulletin American Association of Petroleum Geologists*, Vol. 33, Part I.

Fettke, C. R., 1951, "Pennsylvania," *Bulletin American Association of Petroleum Geologists*, Vol. 35, Part I.

Fettke, C. R., 1952, "Pennsylvania," *Bulletin American Association of Petroleum Geologists*, Vol. 36, Part I.

Fettke, C. R. 1953, "Pennsylvania," *Bulletin American Association of Petroleum Geologists*, Vol. 37, Part I.

Fettke, C. R., 1954, "Structure Contour Maps of the Plateau Region of North Central and Western Pennsylvania," *Topographic and Geologic Survey.*

Finn, Fenton H., 1949, "Geology and Occurrence of Natural Gas in Oriskany Sandstone in Pennsylvania and New York," *Bulletin American Association of Petroleum Geologists*, Vol. 33, Part I.

Freeman, Louise Barton, 1951, "Regional Aspects of Silurian and Devonian Subsurface Stratigraphy in Kentucky," *Bulletin American Association of Petroleum Geologists*, Vol. 35, Part I.

Harding, Richard W., 1950, "Correlation of Bradford Third and Richburg Sands," *Bulletin American Association of Petroleum Geologists*, Vol. 34, Part II.

Linn, Earl H., 1953, "Devonian Oil and Gas Possibilities in Central Pennsylvania," *American Petroleum Institute*, 826-24-A.

Reeves, Frank and Price, Paul, 1950 "Early Devonian Gas in Northern West Virginia and Pre-Devonian Oil Prospects," *Bulletin American Association of Petroleum Geologists*, Vol. 34, Part II.

Stevenson, Robert E. and Willard, Bradford, 1950, "Northeastern Pennsylvania and Central New York Petroleum Probabilities," *Bulletin American Association of Petroleum Geologists*, Vol. 34, Part II.

★ ★ ★

Preparation of geological cross-sections speeded and correlations simplified

Photocopying Replaces Hand-Drafting*

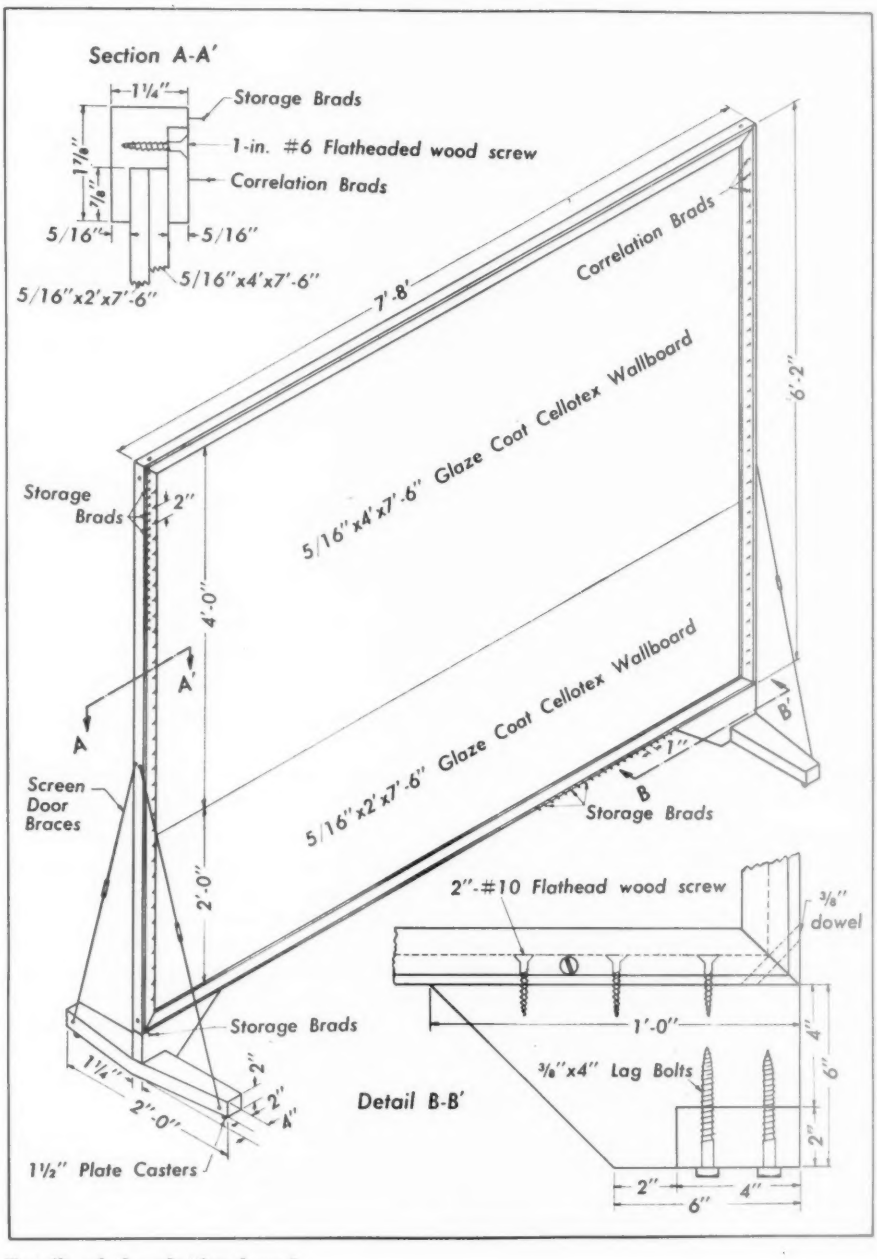
B. OSBORNE PRESCOTT†

CROSS-SECTIONS of underground areas being explored for oil and gas, play an important part in the analysis of geological formations and in the illustration of geologic thought. A great deal of time, however, is consumed in drawing the basic cross-section before the geologist can get to work on his correlations. When preparing these correlations on a cross-section spread out on a table or desk, it is often difficult to view the problem as a whole or even to see more than two or three of the logs under consideration.

Because we have insufficient time to do all of the drafting jobs necessary, a new method for plotting these correlations and recording them photographically was developed. The new method permits a cross-section to be prepared and preserved in permanent form—from a blank board to the final reproduction—in as little as two days. This is a substantial saving over the two to three weeks usually needed to prepare a cross-section by the normal drafting methods.

One reason why this new procedure speeds up the operation is that the entire section can now be viewed at once in its entirety. More than one geologist can work on the same section at the same time. With practice, the correlations can be determined more readily, since facies changes and other anomalous conditions may be viewed in a broader perspective. Any changes in the correlations that are necessary can be made very simply. Instead of erasing a line and drawing a new one, a tack is moved, a cord slides to the corrected position, and the change is completed.

By preserving the plotted information photographically, rather than by hand-drafting a final tracing, the record is quickly made. Moreover, with the plot in the form of an 8 by 10 photograph, containing all the data that would otherwise be contained on a drawing as much as 54 in. wide (or a print made from it), handling and filing the completed cross section are clearly much simplified. The photograph can be easily and quickly reproduced in any size desired, for reports, distribution to other offices, etc.



Details of the plotting board

*This report won honorable mention in the "Photocopy-In-Industry" contest conducted by Peerless Photo Products, Inc., Shoreham, L. I., New York, and has been released to *The Petroleum Engineer* for exclusive publication.

†Shell Oil Company, Oklahoma City, Oklahoma.

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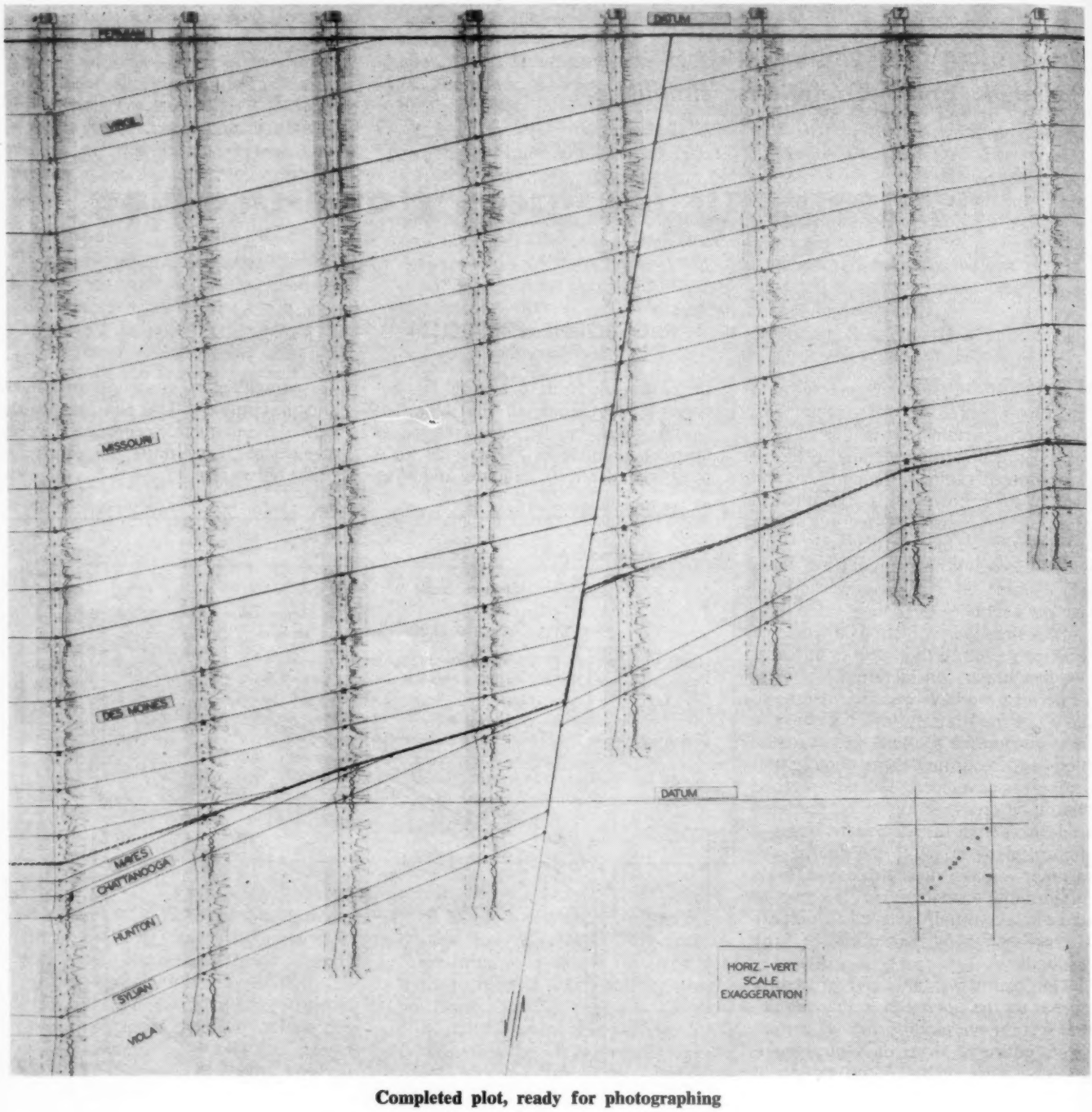

Completed plot, ready for photographing

The new method makes use of a large bulletin board on which the correlations are plotted with the aid of an array of nylon cords, plumb bobs, and thumb tacks. This part of the procedure is not new, and has been used for several years by Shell and most of the other firms in the petroleum industry. We, at Shell, are using five of these plotting boards and it is seldom that you can find a vacant one on which to work.

What *is* new, however, is recording and preserving the plot photographically rather than by drafting, and this part of the operation will be described in somewhat greater detail.

The Plotting Board

Dimensions and specifications for this board may vary with individual tastes, but certain requirements are dictated by the procedure and (in our case) the working location. For maximum usefulness, the dimensions of the correlating surface of the plotting board should have the same proportions as an 8 by 10 photograph. Our boards have to be able to pass through a standard 7 ft doorway, so that the finished board cannot stand more than 6 ft 10 in. high.

Plotting by attaching log charts, legends, and so on to a panel with thumb tacks automatically suggested the use of a material like Celotex wallboard. Since the largest panels of this material available are 4 by 8 ft, three of them are glued together, back to back, with the joints offset, to give a double-thickness board 6 ft deep by 7 ft 6 in. wide. Both surfaces are given a coat of flat white casein paint to eliminate glare, and the board is mounted in a frame of molding strips so that replacement is easy when the surface becomes worn.

Guys tightened with screen-door turnbuckles add stability to the board and also hold it in the plumb (vertical) position, so that the photograph that is taken later will not be distorted.

Thirty correlating lines, of 10-lb test,

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black nylon, casting line, about 11½ ft long, each with a 2-ounce swivel casting sinker attached at one end for a weight, are secured to a like number of brads on the sides (vertical members) of the frames, spaced 2 in. apart. Three or 4 more lines 6 ft long, again with weights, are also needed. Ten lines 11½ ft long of intertwined red-and-white No. 5 Pearl crochet line are used to mark out unconformities.

Cross Section

To begin, one of the black nylon correlation lines is stretched horizontally across the board as a datum or sea-level line. Working from either end, the first log is positioned vertically on the board in proper relation to the datum line and secured with a push pin at the top. One of the 6-ft lines is looped over the head of this push pin and used as a plumb line to align the log in true vertical position. The log is now thumbtacked in place and the plumb line and push pin removed. Using the scale, each of the remaining logs is positioned by the same sequence of operations. With electric logs the heading may be folded under; with sample logs or similar stiff-paper logs, the unused portion is passed over the top or under the bottom of the frame and held in place on the other side of the panel by a thumb tack.

Correlations are indicated with map tacks and each set of correlations is connected with one of the lines. These tacks are not fully pushed in, so that the line can slip while correlating.

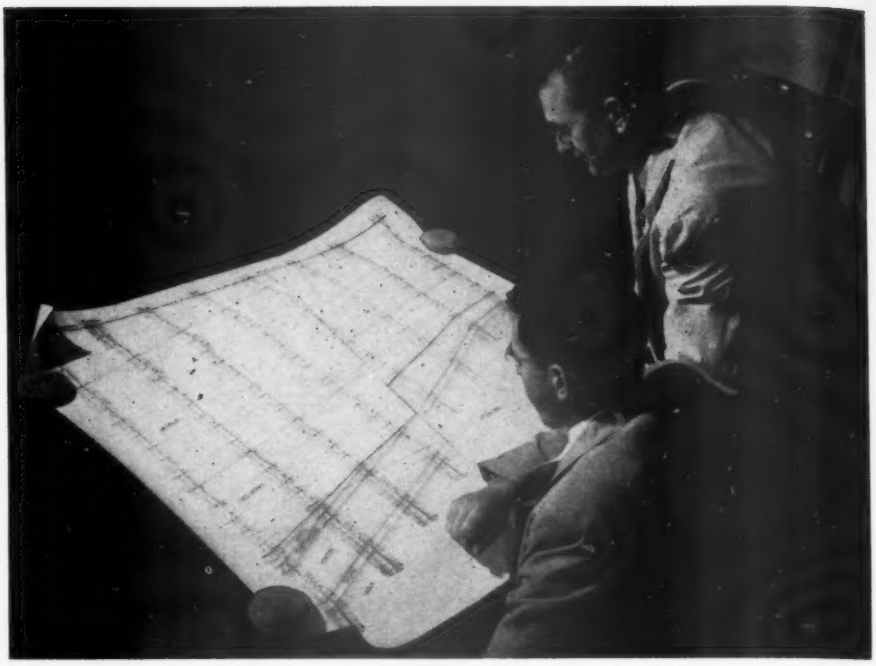
A fault is constructed by the use of one of the six-foot lines; offset correlation lines are held with map tacks.

When all the correlations are completed, lines which extend beyond the end logs are held horizontally with other tacks; the map tacks are then fully pushed in, and signs (legends) are tacked in position on the board. The plot is then ready to photograph.

Making the Photocopy

The 8 or 10 photograph of the finished plot is made on an Ortho Lith film, with an ASA speed rating of 3. Light for taking the picture is furnished by two No. 2 photo-flood lights in reflectors. This light is "painted" over the whole surface of the board during the exposure by moving the photofloods vertically from top to bottom of the board while pointing them toward the outer edges of the board from a central position near the camera. This produces an even, shadowless picture.

Exposure is of the order of 2 minutes at f/45. The negative is developed by inspection in Kodak D-11 developer; time runs between 3½ and 4 minutes at 68 deg F.



Examining the finished ¾ size photocopy

This process yields a negative of extreme contrast with very clear whites and dark blacks, very little background or blocking, and great definition.

The negative is then frisketed or outlined with black or red photographic "Scotch" tape to eliminate unwanted parts of the photograph. An enlargement of this negative up to three-quarters of the full size of the original plotting-board is made on Lith matte film with no important loss of definition. In making this enlargement, the negative is placed in the holder with its emulsion *away* from the emulsion of the matte film. This makes easier the job of adding information in India ink to the matte surface of the enlargement. Erasures and corrections on the matte film are made with erasing fluid or with a sharp knife.

Tulsan Gets Top Award

Ben F. Rummerfield, executive vice president of Century Geophysical Corporation of Tulsa was awarded top honors for his paper, "Reflection Qualify, a Fourth Dimesion," at the recent American Association of Petroleum Geologists-Society of Economic Paleontologists and Mineralogists.

This was the sixth annual award presented by the society, and was given by Paul L. Lyons, Anchor Petroleum Company, SEG president.

Previous winners include Leo J. Peters, Gulf Research and Development Company; Miller Quarles, Jr., Precision Exploration Company; L. Y. Faust, Amerada Petroleum Corporation; Teodor Krey, Seismos GmbH, and Charles B. Officer, Woods Hole Oceanographic Institution.

When all corrections and additions have been completed, final prints are made from the enlargement by any positive reproduction process. They may also be colored, to highlight certain information. The resulting print will compare favorably with cross sections prepared by other methods, such as drafting procedures.

All in all, this method is much cheaper than hand-drafting, as well as faster and more versatile.

If desired, smaller-size prints of the cross section can also be made, for circulation to other offices, etc. These prints are usually made either on 8 by 10 glossy contact paper, or by the diazo process from an 11 by 14 film positive enlarged slightly from the original film negative.

These smaller-size prints are satisfactory when only one person has to read and decipher them. But for illustrating reports, where several geologists must see and discuss the cross section at one time, the small prints are difficult to use and the larger prints, three-quarters of full-size, are much more suitable.

For example: On the original plotting board, 1 in. on the vertical scale represents 100 ft. If we reduce 6 ft of log to 8 in. this means that one-ninth of an inch will represent 100 ft. This scale is not too fine for one man to decipher, with the aid of a hand enlarging lens, but it is extremely difficult for a group of 2 or 3 to comprehend.

Acknowledgement

Assistance of Meyers Photo Shop, Oklahoma City, Oklahoma, in dealing with the photographic problems involved, is gratefully acknowledged.

* * *

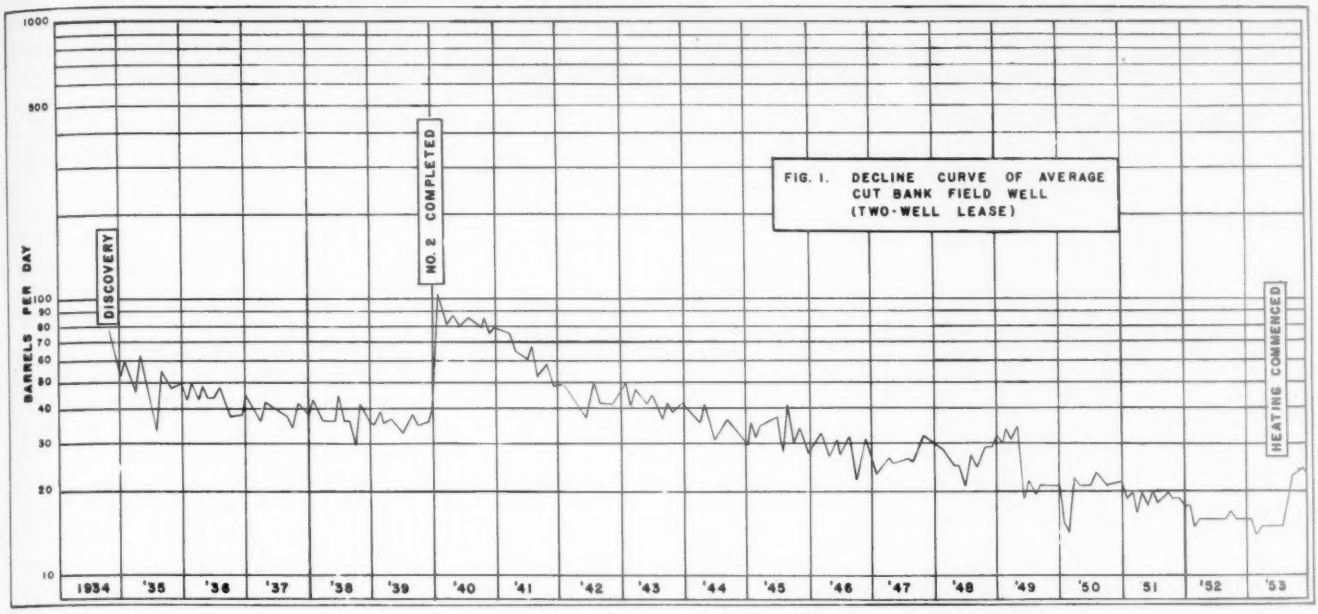


FIG. 1. Decline curve of average Cut Bank field well (two-well lease.)

BOTTOM HOLE HEATERS

Electrical units in Montana wells have measurably increased production and shown substantial return on installation investment

K. G. PARRENT

Abstract

Heating of oil wells to improve production has been practiced in Montana for about the past 5 years. Approximately 135 heaters have been run in wells in northern Montana with a success ratio of about 3 to 1, and economic returns of 300 per cent on the investment. This article deals only with the heating problems and results that have been obtained in northern Montana. The bulk of the work done in this area has been in the Cut Bank field in the Cut Bank sand of Lower Cretaceous age.

WELL heating has been practiced since the early days of the oil businesss. Present day methods may be more exacting than were the older methods, but a great deal of the work still seems to be "cut and try."

Purpose of this article is to discuss electrical heating of oil wells in Montana. Although Montana comprises a very small portion of the Rocky Mountains producing area, the problems encountered and results obtained may be effectively applied to the entire Rocky Mountain region. The theoretical aspects of electrical well heating are beyond the scope of this paper and will, therefore, be considered only briefly.

The majority of well heating data available relate to the Cut Bank field in northwestern Montana, although it is believed that a few wells in other parts of the state have been heated.

The Cut Bank field contains approximately 1100 wells and produced an average of 8 bbl per day per well in December, 1953. Fig. 1 is a decline curve showing the production trend of a typical well in the Cut Bank field. Approximately 90 per cent of the production of the Cut Bank field is derived from the Moulton-Lander-Sunburst, and Cut Bank sands of Lower Cretaceous age with the balance of the production derived from the Madison limestone of Mississippian age.

The Cretaceous oil producing horizons of northern Montana vary considerably in lithology both horizontally and vertically. The Moulton-Sunburst sands, which account for a minor portion of the Cut Bank field production, are typically shaley, silty, medium-to-fine-grained "salt and pepper" sands.

Saturation thickness of the individual sands generally varies up to 15 ft. The Cut Bank sand is the most important reservoir in the area. It is generally composed of quartz and chert grains with varying quantities of accessary minerals present. Kaolininte, the principal cementing material in the Cut Bank sand, is believed to be responsi-

The Author

K. G. Parrent is a consulting engineer in Newcastle, Wyoming. He has attended the University of Montana, New Mexico Institute of Mining and Technology and has a BS degree from Montana School of Mines in petroleum engineering. Parrent has worked in the oil fields in many and varied positions since 1938. He has devoted extensive study to development and operation of electric heaters for wells in the Rocky Mountain region. In 1949 Parrent won an award from the James F. Lincoln Foundation for a paper titled "Design and Fabrication of Arc-welded Steel Masts for Oil Well Drilling Rigs."

EXCLUSIVE

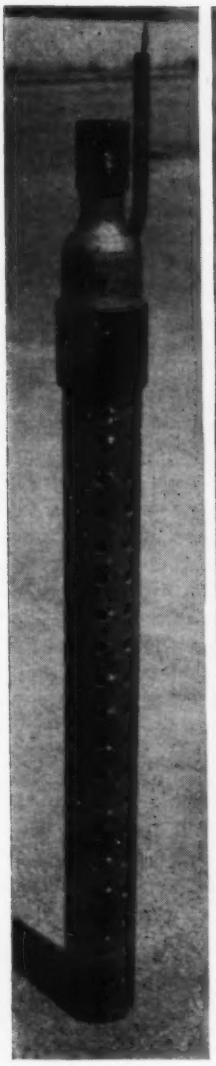


FIG. 2. Shop made.

FIG. 3. Manufactured.

ble for the water sensitive nature of the sand. The porosity of the Cut Bank sand varies from 7 to 25 per cent. The permeability averages 15 millidarcys vertically and 150 millidarcys horizontally.

Most heat applications in Montana oil fields have been opposite the sand face. In theory it is believed that the heat restores the permeability of the sand to the oil by facilitating the removal of paraffin accumulations and water blocks near the well bore. It is believed that the heat applied warms the sand for an undertermined, though probably short, distance away from the well bore. The resulting increase in "bottom hole temperature" may (1) melt paraffin that has accumulated in the interstices, (2) decrease the viscosities and surface tensions of reservoir contents, and (3) decrease the gas-liquid and liquid-liquid interfacial tensions existing between the various phases of the reservoir contents. The foregoing changes in physical conditions tend to increase the production capacity of a well under given pressure conditions. It is evident that extensive controlled laboratory investigations might be conducted regarding electrical well heating.

Electrical well heating was first tried in the Cut Bank field about 1949. Since then, approximately 135 installations have been made. Some 80 per cent of the installations have been economic successes; the remaining installations either did not effect production increases or some mechanical failure occurred before any results were obtained. Cumulative figures, however, are sufficient to put the entire effort "in the black."

Equipment

Equipment used in electric well heating must be of an adequate construction to permit fairly rough handling and still be functional when put into operation. It has been found that each component of the heating equipment must be treated with care and must be considered separately.

Heating Element. Creditable results, as well as failures, have been obtained through the use of both manufactured and custom made heaters. Until recently most of the heaters installed were custom-made throughout or shop-made (Fig. 2) using manufactured elements. Recently several manufactured types of heaters (Fig. 3) have been installed by various operators, but no data on their performance are available yet.

Most of the heaters in the Cut Bank area employ 5 to 10 KW, 230 V, oil immersion, rod-type elements. Five to 10 KW elements deliver adequate BTU and are reasonably priced. Each element is composed of 2 heating rods that are generally wired in parallel to produce a current of 20 to 21 amps and a watt-density of approximately 21 watts per square inch of rod surface. Higher watt densities result in premature failure of the heater. Fig. 4 is a drawing of a typical shop assembled heater.

To effect their isolation from well fluids, heater terminals are enclosed in a pressure-tight housing packed with a plastic, asphaltic, or porcelainic pothead filled. Although many tests have been made to devise a durable housing and to select a satisfactory filler, short circuits caused by fluids accumulating inside the housing are still the main cause of heater failures.

Conductor. The production tubing serves as the negative conductor with the positive lead being an insulated wire passing from the heater terminals through a packing gland in the terminal housing (Fig. 4) and thence to the surface. It is admitted to the atmosphere through another packing gland attached to a side outlet on the casing head. Several types of wire and cable have been used as the positive conductor, with subsurface-pump cable, as well as lighter types of wire having been found serviceable. Numerous installations utilize a No. 8 nylon protected, polyvinylchloride insulated, single strand, solid copper conductor. Several re-runs have been necessary as a result of the plastic insulation being stripped off the single strand conductor during installation. There have been very few failures where armored cable has been used, but the economic merit of its selection is questionable due to its high initial cost. A few of the armored types of cable used are conventional street-light cable, marine conductor cable and spiral-armor cable.

The conductor must be fastened to the tubing for support and to minimize fouling while being run into or removed from the hole. Banding ma-

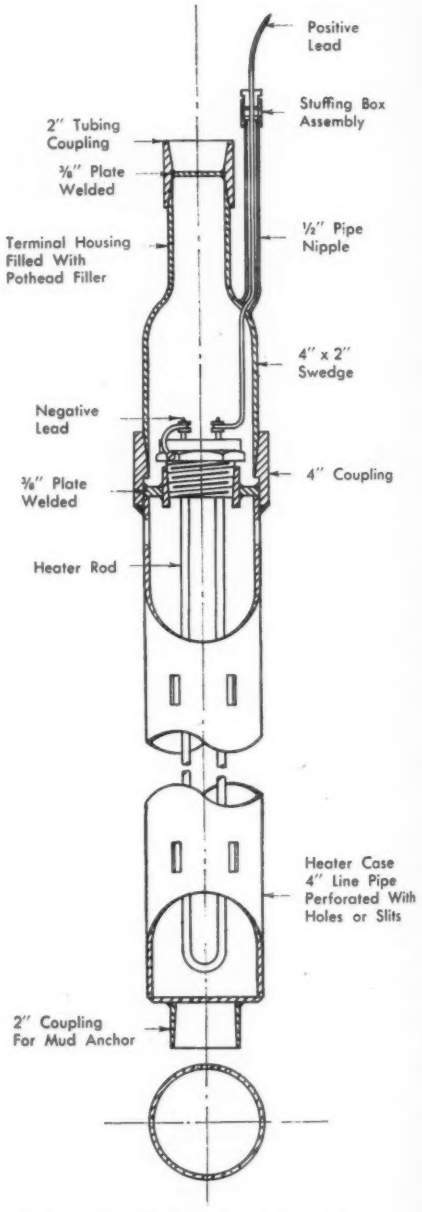
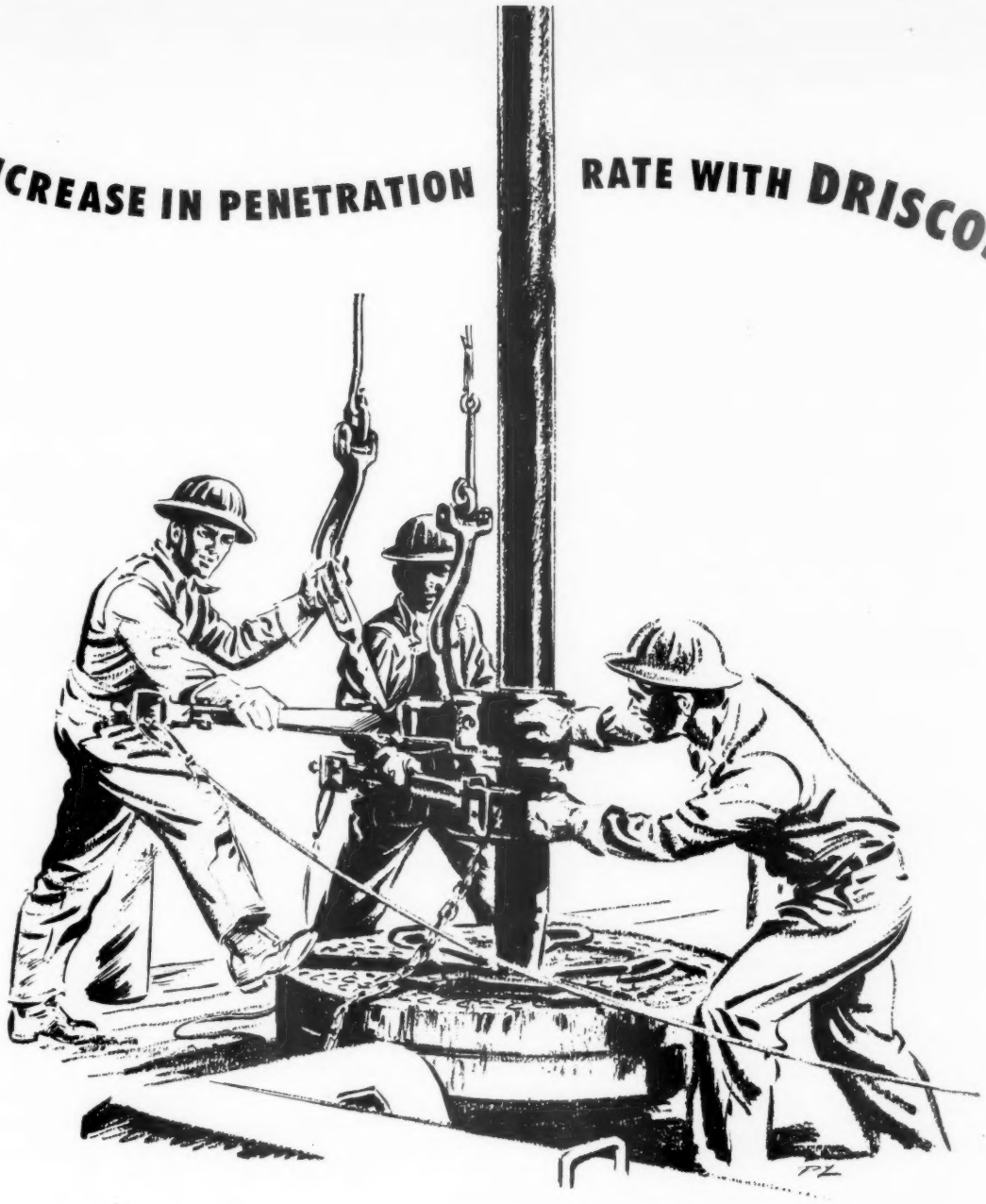


FIG. 4. Electrical formation heater.

25% INCREASE IN PENETRATION RATE WITH DRISCOSE*!



Figures for 10 Texas wells, where characteristics of mud systems were practically identical with respect to viscosities and weights, show that the use of **DRISCOSE** in a mud with a low concentration of solids helped to increase rate of penetration approximately 25%. Water loss was lower, too . . . 6 to 8 cc with **DRISCOSE** as compared to 10 or 12 cc where **DRISCOSE** was not used. And in addition, wells that mudded up at 10,000 feet with **DRISCOSE** continued to drill just as fast as when they were using clear water . . . no slow-up of penetration due to mudding with **DRISCOSE!** Write for complete information.

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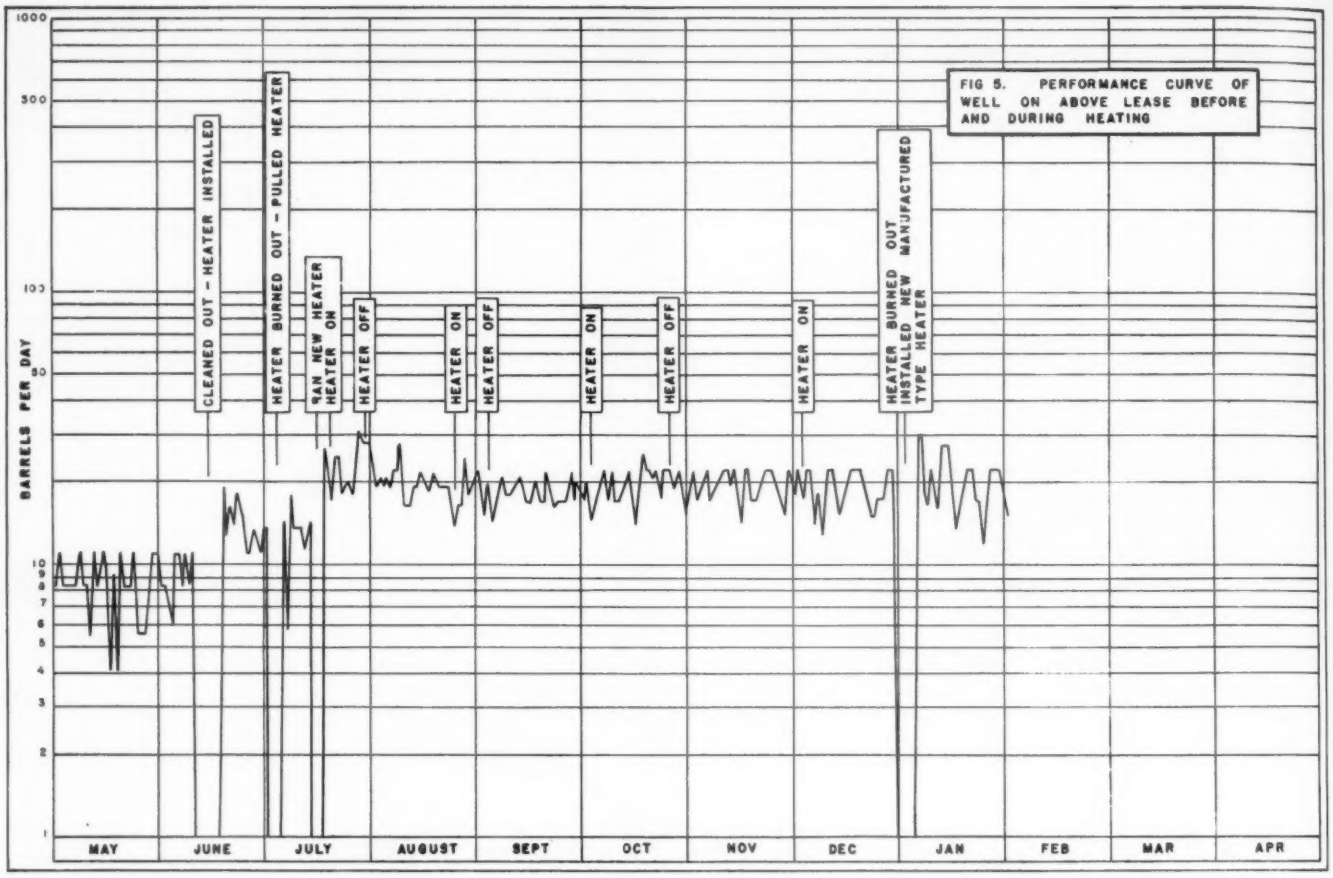

FIG. 5. Performance curve of typical well in the Cut Bank field.

chines have been found quite adaptable as the steel band employed is sufficiently strong and an ample "friction hold" can be exerted on the lead. In the case of the single strand, plastic-insulated wire, various types of gasket materials and tapes have been used to protect the insulation from tension of the band. No extra precautions are necessary to protect the armored-type cable when clamping it to the tubing.

Tubing Centralizers. As further protection for the lead, many operators install centralizers on the tubing. Such centralizers may consist of sawed wooden blocks some 12 in. in length fitted over the collar of every joint (occasionally centralizers on every other joint are adequate) and fastened in place with either hose clamps, wire, or steel bands. Another centralizer is the commercially available type made of molded rubber or plastic which is slipped over the thread end of each joint before makeup. This type is about 12 in. in length and has 3 wings on it. Still another servicable type, and probably the cheapest, consists of 3 steel wings welded to each collar where needed.

Packing Glands. As the annulus pressure in the wells in the Cut Bank area seldom exceeds 35 psi, it is possible to use a simplified, low-pressure packing gland to pass the conductor from the annulus to the atmosphere at the well head. The packing gland on the heater terminal housing must prevent the entrance of well fluids and vapors into the housing and is much more critical than the packing gland described above.

Installation

The heater is generally attached to the bottom of the tubing, but some operators prefer to run a mud anchor below the heater. After the heater is attached to the tubing, the "pig tail" from the inside of the terminal housing is spliced to the positive lead, and lead and tubing are lowered into the hole with occasional stops to check the continuity of the circuit. During "running in," at least one extra man is required to handle the positive lead.

Operation

As is typical of wells, each must be treated separately and experimented with until the optimum heating requirements are determined. It has been found that some wells must be heated continually whereas others need to be heated only one month out of four. Still others react more favorably to being heated daily while the lifting equipment is idle.

Operational Hazards

The majority of heater failures has been due to short circuits resulting from fluid leaking into the terminal housing. Such leaks have been found to occur at either threaded or welded joints. As most of the wells in the Cut Bank area were completed "bare foot," heater failures due to mud and sand accumulations have also been quite numerous. On occasion walls of the hole will cave and bury the heater thereby preventing the dissipation of heat from the rod. The resulting local super heating causes the rod to burn out. As stated previously, wire failure is occasionally responsible for heater failures.

Well Selection

Although considerable effort has been expended in attempting to choose wells to heat, no definite criteria have resulted. It appears that, as a rule-of-thumb, the originally better wells react more favorably to heating than do the originally poorer producers.

Position of Heater

In order to obtain maximum efficiency from heat applications, the heater must be placed in the proper position relative to the sand face. The most effective position may or may not

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be opposite the best pay interval. Several operators prefer to place their heaters on the basis of sand development and saturation indicated on radiation logs of their wells. Other operators choose to install a few pup joints and move the tubing up or down in the well to experimentally locate the most satisfactory position for heating.

Results of Heating

Although a few operators have not obtained favorable results from heating their wells, the overall results have been very gratifying with the economic depletion of most wells being retarded by as much as five years. It is believed that the increased production resulting from work-over operations has been sustained by the subsequent heat applications.

Studies conducted by one large operator concerning its heater program indicated the following: Approximately $3 net profit per $1 invested including cost in research and development of heater and an average 300 per cent initial increase in production per installation. (Some heaters failed.)

From 65 "heated' wells chosen at random, the present total average daily production was found to be approximately 900 bbl per day whereas these same wells would be producing a total of 300 bbl per day (from projected decline curves) had they not been heated. Fig. 5 graphically illustrates the performance of a typical well in the Cut Bank field before and after the commencement of heat applications.

Cost of Materials

(Over and above customary cleanout costs—(approximate figures)

Heater complete	$150	$150
Conductor	$240	$240
Controls and surface switch		$ 25
Extra labor for installation—8 hrs @ $1.75		$ 14
Extra rig time for installation—8 hrs @ $11		$ 88
Centralizers—50 @ $2		$100
		$617

Acknowledgement

The author is grateful to the independent operators and to major companies of the Cut Bank area for the generous assistance received. * * *

Lion Office in Oregon

Lion Oil Company has established a new office of the Production and Exploration division in Portland, Oregon, according to J. E. Howell, company vice president.

The Portland office is headed by James W. Dowden, formerly geologist in Lion's Bismarck, North Dakota district office. He will serve as an observer in the Northwest for Lion Oil's expanding production and exploration activities. His office is part of the company's Rocky Mountain region.

Relatively new material, polyester resin, serves well in oil field use where corrosion is factor

Lightweight and ease of transportation as well as strength of pipe are demonstrated in these pictures.

Plastic Pipe Proving Itself

SEVERE corrosion by salt water and hydrogen sulfide in oil fields has little affect on a new type reinforced thermosetting resin pipe. Developed specifically to combat corrosive conditions, this pipe is made by a centrifugal molding process.* Because of the chemical resistance of the polyester resin used in its manufacture, the pipe is not affected by sulfur and salt-laden fuels, oil and oil products, natural gas, soil alkalies, or acids.

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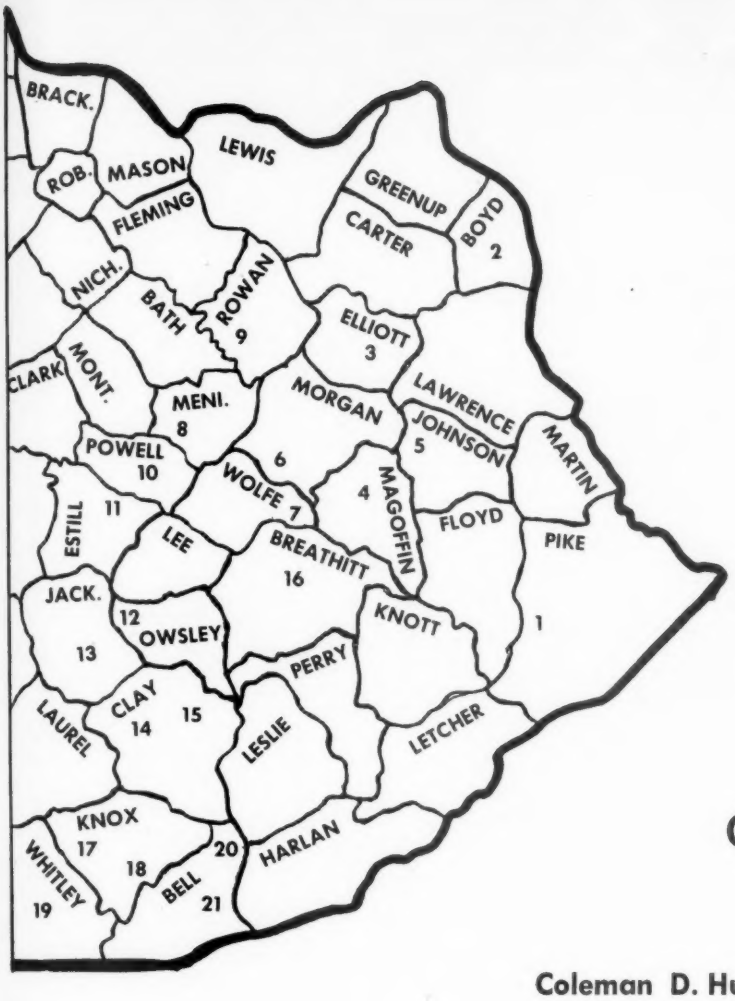
Two grades of pipe line are available for operating pressures of 100 or 200 psi. Oil well tubing is available for operating pressures to 300 psi. Both classes of tubular goods are available in sizes 2⅞, 3½, and 4½ in. OD. The temperature range for recommended operating pressure is between minus 65 and plus 130 F. Where it is desired to operate in the temperature range of 130 to 180 F the recommended working pressures should be decreased 50 per cent. The coefficient of thermal expansion of Fibercast pipe is essentially the same as steel. * * *

*The Fibercast Corporation, Sand Springs, Oklahoma.

XUM

Development of Natural Gas Fields of Eastern Kentucky



Coleman D. Hunter

Gas Fields of Eastern Kentucky

1 — Big Sandy
2 — Ashland
3 — Isonville
4 — Ivyton
5 — Flat Gap
6 — Grassy Creek
7 — Lee City
8 — Rothwell
9 — North Triplett
10 — Janet
11 — St. Peter
12 — Turkey Knob
13 — McKee
14 — Burning Springs
15 — Oneida
16 — Taulbee
17 — Indian Creek
18 — Artemus-Himyar
19 — Williamsburg
20 — Red Bird
21 — Bell County

EXCLUSIVE

THE gas producing region in Eastern Kentucky, as shown on map, lies on the western flank of the Appalachian geosyncline and on the eastern flank of the Cincinnati Arch. All of the sedimentary gas producing sands, limestones, dolomites, and shales are of Paleozoic, and ninety per cent of the surface formations throughout the gas fields are of Pennsylvanian age.

From the Ordovician crest in Central Kentucky, eastward, the rocks dip into the Appalachian trough at a rate of from 20 to 35 ft per mile. The rate of dip of each formation varies because of local structure and unconformities.

In the rejuvenated Kentucky River gorge, 20 miles south of Lexington, on the crest of the Cincinnati Arch, the oldest sedimentary rocks of Kentucky are exposed. These rocks are those of the High Bridge group (Black River). From this location eastward, for 40 to 50 miles, most of the gas producing horizons of the Silurian, Devonian, Mississippian, and Pennsylvanian are exposed in outcrop.

Throughout the entire Paleozoic period of deposition the seas changed many times from deep seas, which extended high upon the arch, to low seas whose shore lines went far down in the trough. This oscillatory motion, especially during late Silurian and early Devonian time, is responsible for the southeastward thickening due to progressive down-sinking of the geosyncline. In less than 100 miles eastward from the outcrop the Devonian Carbonaceous shales thicken over 800 ft.

Other formations present in the eastern gas fields are not found in the outcrop because deposition took place when the seas were shallow and low on the arch and were later covered by younger rocks when the seas extended farther westward upon the arch. In the truncated Devonian and Silurian dolomites and sands some of the producing oil and gas fields of Eastern Kentucky are found.

That Eastern Kentucky has been subject to great deformation is apparent by many structural features other than the two major features mentioned.

Two important structural features are the Kentucky geosyncline and the Middlesboro Basin. Both strike parallel with the Pine Mountain overthrust, the former lying on the northwest and the latter on the southwest.

Most of the folding appears to have been the result of movements that occurred during the Appalachian revo-

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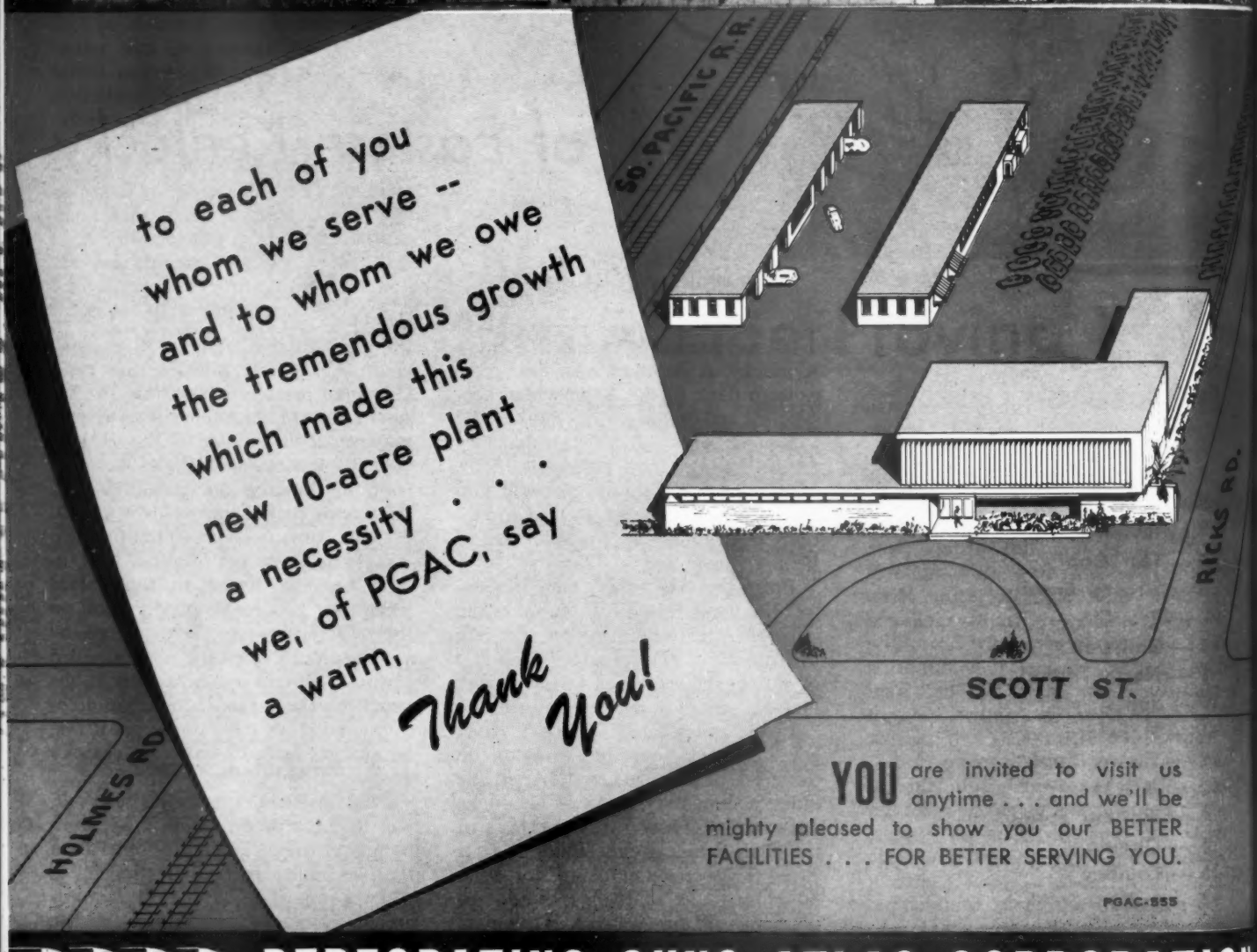

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lution. This deformation was accompanied by widespread thrust faulting, both high-angle and low-angle types. The Pine Mountain fault is an example of the latter where there has been a low-angle overthrust from the east to the west, with horizontal displacements of at least six miles.

Examples of normal faulting in Eastern Kentucky are the Irvine-Paint Creek zone, and others of less magnitude, such as the Little Sandy fault in Elliott County, the Blaine Creek in Lawrence County, and the Johnson Creek fault in Magoffin County.

The two most pronounced anticlines and domes are located on the Paint Creek uplift in Elliott, Johnson, Lawrence, and Magoffin Counties, upon whose western flanks the Weir oil fields of Eastern Kentucky are located.

The other is the Rockcastle River uplift of Clay and Laurel counties, on which the Corniferous Burning Spring gas field is located and on which (in Clay and Laurel counties on the Raccoon Dome) two Knox dolomite oil wells have been drilled.

Regardless of the relation of structures to gas production in Eastern Kentucky, it is the writer's opinion that sedimentary conditions are the most important factors, especially in the Devonian Shale Big Sandy gas fields. Local structures apparently show no relation to production, and on the most pronounced Paint Creek uplift shale production encountered is too small to be of commercial value although over 400 ft of black Corniferous Devonian shale is present.

DEVELOPMENT

The development of the different gas fields in Eastern Kentucky is tabulated in the order listed in Fig. 1, with the exception of No. 1—Big Sandy gas field, from which over 90 per cent of the annual gas for the entire State of Kentucky is produced.

No. 1—Big Sandy Gas Field

Located in Martin, Johnson, Magoffin, Floyd, Pike, Knott, and a small area in Perry and Letcher counties, Kentucky, covers a developed area of over 700,000 acres in which, at the close of 1953, 5378 wells have been drilled for gas. The following development results were experienced:

No. Wells	Production formation	Open Flow Developed: Total Mcf	Open Flow Developed: Average Mcf
330	Salt Sand (Penn.)	258,477	783
567	Maxon (Miss.)	945,017	1666
373	Big Lime (Miss.)	608,810	1632
3172	Black Shale (Dev.) (Weir & Berea (Miss.)	1,179,444	371
266	(Corniferous (Dev.) (Big 6 (Silurian)	418,384	1573
670	Dry Holes		
		3,410,132	634

The original rock pressures of different gas producing horizons vary, depending on their location in the field, and are approximately:

Devonian shale, from 550 psig to 760 psig; Lime and Dolomite production, from 400 psig to 640 psig; Sand Stone production, from 280 psig to 600 psig.

The average depth of completed shale wells in the northern part of the field is 2100 ft while 40 miles to the most southern developed area in Pike County the depths average 4000 ft.

Shooting of Devonian Shales: The one factor primarily responsible for the results experienced in the Devonian shales is the effect of shooting the 400 to 700 ft of rich black carbonaceous shale section with from 5000 to 8000 lb of gelatinated nitroglycerine.

The following statistical results show the importance of this practice:

As of the end of 1953, in the Big Sandy gas field, 3553 Devonian Black Shale wells have been drilled. Of this total amount only 156, or 4.3 per cent, were natural producers which did not require shooting. The average open flow of the 156 natural wells was 1305 Mcf. The remaining 3395 shale wells, *before shot,* had an average open flow of 57 Mcf and the average *after shot* was 259 Mcf. Of the 3395 shale wells shot, 1388, or 39 per cent, had no measurable open flow before shot; 2805, or 76.1 per cent, had less than 100 Mcf before shot. After shooting, 1090, or 30.7 per cent, had less than 100 Mcf, of which 349 wells, or 9.8 per cent, were classed as dry holes. Most shale wells, which will have an open flow of less than 50 Mcf after blowing open for 24 to 36 hr, are not considered commercial and are usually abandoned as dry holes. The average life of shale producing wells will exceed 25 years.

Acidizing the Mississippian Big Lime: Acidizing the Big Lime gas producing horizons has been common practice since 1937 and, although the writer does not have statistical information on the results experienced for the 373 Lime wells completed as pro-producers in the Big Sandy gas field, the following statistics on 201 of the Lime wells treated are comparable for the total.

The average open flow for 201 Big Lime wells, before treated, was 218 Mcf as compared to 724 Mcf after acidizing, or an increase of 506 Mcf per well.

Sand Production: In the development in the Big Sandy gas field the practice of shooting the Salt Sand, Maxon, Weir, and Berea is not general for, in the drilling, if only small wells are encountered, the well is always drilled on for the 85 per cent chance of success in either the Big Lime or the Black Shales.

During the past year the fracturing of sandstone and dolomites in oil wells in Eastern Kentucky has been fairly successful and, with some improvement in application, cost, and technique, and fracturing of similar small sand and dolomite gas wells will in time become a more general practice.

Production and Reserves: During 1953, Kentucky produced 71,335,066 Mcf of gas, of which the Big Sandy gas field produced 67,925,938 Mcf.

The second largest producing area are the fields in Clay and Knox counties which produced 1,907,128 Mcf. The remaining 1,500,000 Mcf was estimated for all other producing fields and wells in the entire State of Kentucky.

The total gas which has been produced from the Big Sandy gas field has been estimated at 1,200,000,000 Mcf and the estimated remaining reserves on the proved 700,000 acres are 450,000,000 Mcf, which would give an estimated ultimate recovery of 2350 Mcf per acre.

Although the writer has no actual production history of recovery on many developed small producing gas fields outside the Big Sandy gas field, it is reasonable to estimate the undeveloped gas reserves of Eastern Kentucky, from studies of many exploratory tests, stratigraphy, and structural similarities to developed field, as over one and one-quarter trillion cubic feet.

No. 2—Ashland Gas Field

In the Ashland gas field in Boyd County, Kentucky, which was developed between 1924 and 1929, 233 wells were drilled, 80 per cent of which were commercial producers. With the exception of a small amount of gas from the Pennsylvanian Salt Sands and Mississippian Big Injun, over 90 per cent of the gas produced comes from the Devonian Shales. Sixty-six of the producing wells were drilled within the city limits of Ashland and Catlettsburg, Kentucky, and the field extends on northeast some 20 miles into Ohio and the city of Huntington, West Virginia. The depth of wells varied from 1800 to 2000 ft; open flow, 150 Mcf to 1500 Mcf; rock pressures, 600 psig to 800 psig. The field at this time is over 90 per cent depleted.

No. 3—Isonville Gas Field

Located in southeastern Elliott County is Isonville gas field, also described as the Newcombe gas field in some publications, which was developed between 1928 and 1936. Of 35 wells drilled, 24 were gas wells produc-

ing from the Mississippian Weir Sand and the Corniferous. The deepest Corniferous wells did not exceed 1500 ft.

This field is located on the Burke Adkins Dome and its northern extension is along the axis of the Paint Creek uplift. In the development for gas, small oil shows were often encountered in the Weir Sand and were not shot or considered commercial. During the past five years, with favorable results experienced in shooting the Weir oil pays, and later, from exceptionally good results obtained from fracturing, this area of Elliott County has become the most active new oil development in Eastern Kentucky.

Over 100 oil wells have been drilled in the past 5 years increasing oil production from 18,000 bbl to 85,735 bbl for 1954. The gas field is 95 per cent depleted.

No. 4—Ivyton Gas Field

Ivyton gas field in Magoffin County, and a northern extension known as the Winn Gas Field, in Johnson and Magoffin counties, are located on the Ivyton and Winn Domes on the crest of Paint Creek uplift. Over 100 commercial gas wells, producing from the Weir Sand at depths of from 950 to 1100 ft, were drilled between 1917 and 1925 along with the extensive Weir oil development which lies on the west flank of the Paint Creek uplift. This production has been commercially depleted for the past ten years. Production from the Ivyton field is included in the Big Sandy gas field development statistics. Three deep Knox dolomite exploration wells, drilled on the Paint Creek uplift, were dry holes.

No. 5—Flat Gap Gas Field

Flat Gap gas field of Johnson County, which is also referred to as the Redbush gas field, located in northwestern Johnson County, is located on the largest Paint Creek Uplift closure —the Laurel Creek Dome. Of the 243 wells drilled for gas, 215 were producers from the Weir sand at depths of from 750 to 900 ft. Open flows of from 200 Mcf to 1000 Mcf were encountered and the original rock pressure was 205 psig.

This Weir gas field, with the other two above-described Weir gas fields on the Paint Creek Uplift, has also been commercially depleted for over 10 years. What remaining gas is left is being used for power and repressuring in the adjoining Weir oil fields.

The total estimated recoverable gas from all the Weir producing field has been estimated at approximately twenty-five billion cubic feet.

The Barnetts Creek gas field—No. 10—and the Royalton Beetree gas field —No. 13—are included in statistics with the Big Sandy gas field. The Swamp Branch gas field is also included in the Big Sandy gas field and all producing formations are similar to those in the Big Sandy field.

No. 6—Grassy Creek Gas Field

In south-central Morgan County, Grassy Creek gas field, was discovered in 1921 and developed by the end of 1936. Over 80 Corniferous tests were drilled to the Corniferous at depths ranging from 1300 to 1545 ft. Sixty-five of the wells were commercial, developing an open flow of over 26,000 Mcf. The original rock presure was 430 psig. Production from this field, when marketed, was very short lived as the wells were located on a low terrace and were drowned out with water in a short time. It is doubtful if the amount of gas recovered justified development cost.

No. 7—Lee City Gas Field

Lee City field is at the head of Red River in eastern Wolfe County, was developed between 1940 and 1943. The 12 shallow Salt Sand producing gas wells, completed at depths of from 450 to 500 ft, developed a total open flow of 2339 Mcf. The original rock pressure for the field is 83 psig. The nearest market is a high pressure transmission line 14 miles to the north and compression would be required to deliver this low pressure gas into the system. To date, the wells are still shut in without a market.

No. 8—Rothwell Gas Field

Rothwell field is located in southwestern Menifee County and extends into northern Powell County to include the Red River gas field. The field was the oldest commercial gas field in Eastern Kentucky and was discovered in 1904. Over 125 producing gas wells have been drilled producing from the Corniferous at an average depth of 500 ft. The field covers an area of over 15,000 acres and is now being used for gas storage.

No. 9—North Triplett Gas Field

North Triplett field is located in northwestern Rowan County, was discovered in 1934. During 1934 and 1935, 9 gas wells were completed in the field producing from the Corniferous at depths ranging from 250 to 350 ft. Original open flows were from 70 Mcf to 400 Mcf and the original average rock pressure was 43 psig. Gas in insufficient amounts was marketed 5 miles into the town of Morehead for several years before the field was depleted and abandoned.

No. 10—Janet Gas Field

Janet field in south-central Powell County, was developed between 1929 and 1934. Of the 36 wells drilled into the Corniferous at depths of from 500 to 550 ft, 21 producing gas wells developed a total open flow of 8000 Mcf. The original rock pressure of the field was 75 psig. Gas was used for both domestic and commercial use in the town of Stanton and for repressuring an oil well in the near Big Sinking oil fields. This field was depleted in 1949.

No. 11—St. Peter Gas Development

St. Peter field is in the Furnace Oil Pool in Estill County, just south of the Janet Gas Field, was discovered in 1946-47. Sixteen St. Peter gas wells developed a total open flow of 99,768 Mcf with a rock pressure of over 750 psig. The average depth of St. Peter sand in this field is 2950 ft. Gas from this field has only been used for repressuring in the adjoining Big Sinking oil fields because it is 40 per cent CO_2 and has less than 600 Btu content.

No. 12—Turkey Knob Gas Field

This field is located in northwestern Owsley County and was discovered in 1917. At the end of 1936, 47 gas wells and 20 dry holes had been drilled. The production from the Corniferous, at depths ranging from 1250 to 1400 ft, had an average open flow per well of 750 Mcf and the average rock pressure was 300 psig. During 1921-1923, the gas production was utilized for the manufacturing of carbon black. From 1923 until 1927, the field was shut in until a pipe line to Central Kentucky was constructed. This field was depleted and abandoned in 1949 after a deep test of older formations to the St. Peter horizons had been drilled.

No. 13—McKee Gas Field

The McKee field, located in central Jackson County, was discovered in 1933. The first well made 300 Mcf from the Corniferous at 790 ft. The original rock pressure was 110 psig. At the end of 1943, 26 producing Corniferous wells were completed and, between 1943 and 1946, the field produced 1,545,000 Mcf, at which time the field was commercially depleted and pipe line system and compressor station were removed.

No. 14—Burning Springs Gas Field

Burning Springs field on the Rockcastle River Uplift in northwestern Clay County, was first discovered in 1898 when gas was found at 2200 ft in the Corniferous. Gas was utilized locally until 1930 when the old Cumberland Oil pipe line was converted

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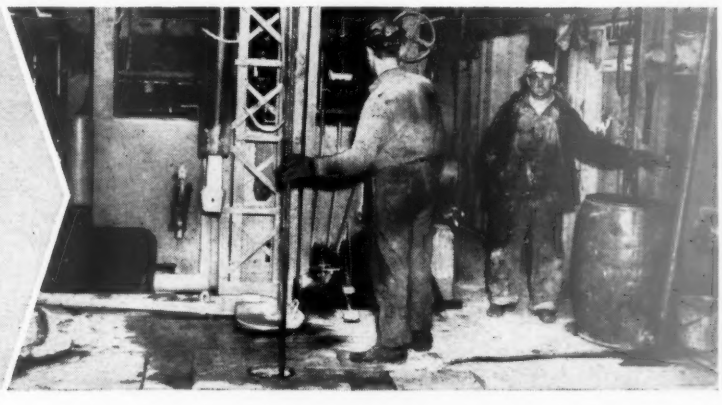

into a gas line to serve Somerset, Kentucky, with domestic gas. A total of 2 Big Lime, 11 Corniferous, and 12 dry holes have been drilled. In 1945, a deep Knox dolomite test on the structure was unsuccessful.

No. 15—Oneida Gas Field

The Oneida gas field is located 7 miles east of Burning Springs in Clay County on the southern flank of Rockcastle River Uplift. Over 80 gas wells and 18 dry holes have been drilled since 1930 and the field has been extended east into Leslie County. The greatest percentage of production is from the Corniferous and is delivered to Central Kenutcky.

No. 16—Taulbee Gas Field

Located in northern Breathitt County is Taulbee field also known as the Big Six Gas Field. Prior to 1920, 7 gas wells, producing from a sandy dolomite with quartz pebbles, located at the bottom of the Silurian Niagaran formation, developed a total open flow of over 20,000 Mcf with an original rock pressure of 550 psig and were connected by pipe line to the north. The name "Big Six" was derived from six men, original operators and drillers, who discovered the new field and pay, as they were all reported to be over six feet tall. By the end of 1930, this field was depleted and the pipe line removed. Since that time, in central Breathitt County, over 10 producing Big Six gas wells have been drilled and a part of the production delivered for domestic use to the county seat at Jackson, Kentucky. The removal of the pipe line in 1930 has retarded the development of a most potential gas area.

No. 17—Indian Creek Gas Field

The Indian Creek field of northwestern Knott County produced gas from the Mississippian Big Lime at depths of from 1450 to 1500 ft. This field was discovered in 1927 and, at the end of 1936, 4 of the 9 wells drilled developed a total open flow of 8245 Mcf and the original rock pressure was 285 psig. Gas from this field, before depletion, was piped to the nearby towns of London and Corbin, Kentucky.

No. 18—Artemus-Himyar Gas Field

Artemus-Himyar field of south-central Knox County, although small in comparison to the Big Sandy gas field, is second in importance as present gas producers in Kentucky. Since the discovery in 1931, when the first well came in producing 1800 Mcf from both Maxon and Corniferous sands, over 100 producing gas wells have been drilled. In 1949, the field was extended by the drilling of 11 gas wells, which developed a total open flow of 17,597 Mcf; and although (because of small town lots and small farms) the field has been 35 per cent over developed, it is still producing over a billion cubic feet annually.

No. 19—Williamsburg Gas Field

Whitley County's Williamsburg field was discovered in 1902, producing oil from Salt sands at 300 to 500 ft. Some of these shallow oil wells were later deepened to depths of from 1200 to 1300 ft into the Mississippian Big Lime where gas was encountered. During 1922 to 1924, gas was used to manufacture carbon black and later was used for domestic consumption in the town of Williamsburg. Both oil and gas wells are now depleted.

The Author

Coleman D. Hunter, who has been chief geologist for the Kentucky West Virginia Gas Company for 28 years, finds the exploration and development of the company's approximately one million rugged mountain acres in Eastern Kentucky "as interesting and exciting as it was in the horseback and oxen days of 1926."

Hunter began his career with the Ivyton Oil and Gas Company, which became the Kentucky West Virginia company in 1927, as assistant geologist in 1926.

Hunter was graduated from the University of Kentucky with a bachelor of science degree in geology. Prior to graduation in 1926 he worked as a roustabout, scout, and tool dresser in Osage, Oklahoma. Also between school years he worked for the Kentucky Geological Survey and made road and stream maps of Clark, Hart, Taylor and Boyle counties, Kentucky.

He has been author or co-author of annual reports on oil and gas development in Kentucky or Eastern Kentucky for AIMME since 1936.

No. 20—Red Bird Gas Field

The Red Bird field of northern Bell County was discovered in 1930, production being encountered in the Mississippian Big Lime at a depth of 2662 ft with an open flow of 912 Mcf and a rock pressure of 525 psig. In the spring of 1936, three additional wells were drilled, one of which was a dry hole and the other two were small Big Lime producers. This development was before the practice of treating Lime production with muriatic acid had been established. At the end of 1953, this field was still shut in.

No. 21—Bell County Gas Field

In northeastern Bell County, the Bell County field, located from 3 to 12 miles south of the old Red Bird Gas Field, has been developed in the past 3 years. Eleven wells have been drilled, 4 of which were dry holes, 3 productive from the Big Lime, 2 from the Corniferous, and 2 from both the Corniferous and Big Lime. Over 4000 Mcf in open flow has been developed and, during 1954, the pipe line system from Knox County has been extended into Bell County.

RECENT EXPLORATION

During 1954, Eastern Kentucky experienced the most extensive exploration for gas in its gas development history. In Harlan County, one exploratory Corniferous test was dry and the second well has been completed as a Devonian Shale producer, thus extending the productive gas potentiality of the shale far to the southwest. In Clay County, two small wildcat Corniferous producing wells have been completed and three test wells are being drilled. Two exploratory Corniferous gas wells have been completed in Leslie County and four wildcat locations are being drilled. In Breathitt County, one exploratory Corniferous gas, one oil, and two dry holes were drilled, and three wildcat locations are now drilling.

During 1954, in the Big Sandy gas field, as of November 5, 1954, there have been 140 gas well completions and 19 dry holes drilled. The total open flow for the 140 wells is 76,668 Mcf. In the Artemus-Himyar gas field, two Corniferous productive wells, developing 632 Mcf, and two dry holes have been drilled. At the present time there are over 50 wells being drilled for gas.

The average Btu content of natural gas in Eastern Kentucky will exceed 1150, making it most suitable for hydrocarbon extraction.

CONCLUSION

When the writer started working in the gas fields of Eastern Kentucky in 1926 the future gas reserves were estimated as sufficient for 25 years. After twenty-eight years, the remaining reserves are still estimated as sufficient, at the present rate of production, for 25 years or more. Perhaps the difficulty of knowing what the reserves really are is best explained in "Natural Gas Symposium,' which quotes Francis Bacon as follows:

> "Man is the minister and interpreter of nature, does and understands as much as his observations on the order of nature . . . permit him; and neither knows nor is capable of more."

* * *

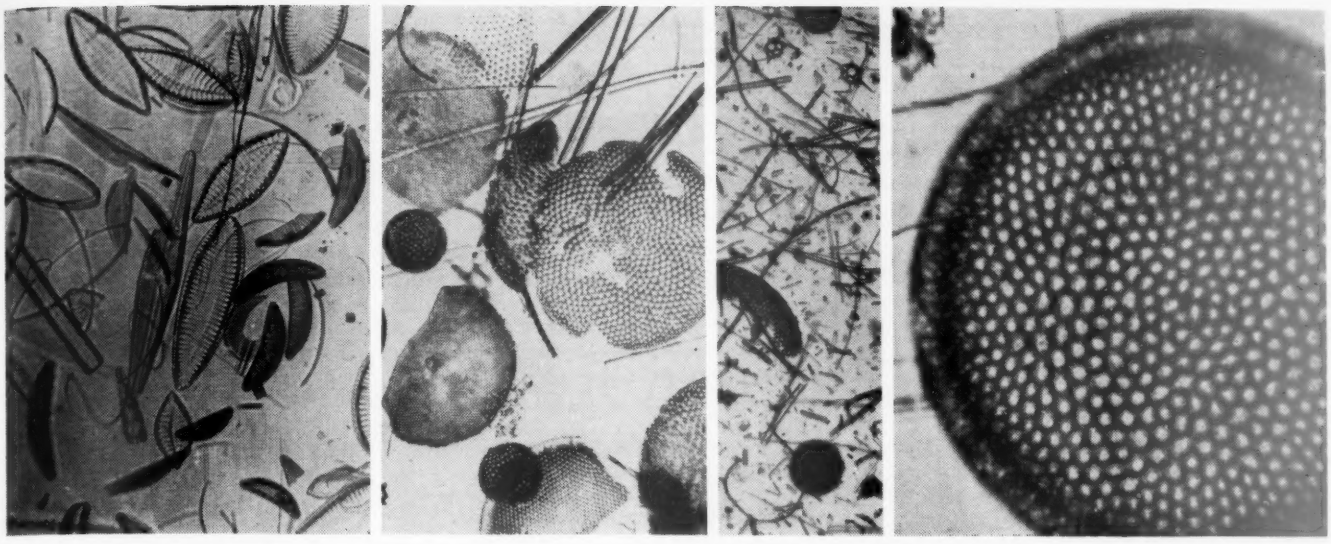

FIG. 1. Photomicrograph showing typical diatoms most satisfactory for diatomite filteraids. The section on the far left illustrates several types of fresh water diatoms. The three right sections picture those of marine origin. On the far right is an enlarged view of a single diatom of the coscinodiscus type.

Diatomaceous Earth Filtration of Water for Sub-Surface Injection

A. F. ALCIATORE,* M. B. HARRIS* and W. E. WALLIN*

PRESSURE filtration of water for sub-surface injection utilizing diatomaceous earth (diatomite) filteraids is a process of considerable merit with increasing interest. This type of filtration operation has long been established in general industrial production. It is a primary means of clarifying such products as sugar liquors, syrups, antibiotics, and other pharmaceuticals, beer, heavy chemicals, oils of all kinds, and many others.

In general water filtration typical applications concern water supply for medium and small municipalities,[1,2] paper mill "white water,"[3] swimming pools, and the condensate from reciprocating steam engines. A successful history covering from 5 to 15 years is established on these applications. Filtration of petroleum refinery slop oils and waste waters[4] is also established and filtration of injection waters is now showing increasing development because of certain operating advantages.

The system of filtering injection waters with diatomite has several advantageous features. First, it offers a means of obtaining as high a degree of clarity as may be desired. Second, the filter system is flexible. It can be installed in small or large units, singly or in multiple, to form a system to suit the size of the project. It offers a high ratio of filtering surface to size of filter and is, therefore, compact, so as to be easily and economically enclosed for protection from the weather. It requires less backwash water to clean than the conventional sand filter. Due to the high absorption properties of diatomite, it can handle small amounts of oil which would under the same circumstances plug a sand filter system.

These features make the process one which merits particular consideration in the following applications:

(a) For the polish filtration of water previously filtered by conventional means but requiring a higher degree of clarity.

(b) For the complete filtration of water requiring a high degree of clarity, or any water carrying a small amount of oil either free or emulsified.

(c) For small installations, or those requiring a compact unit.

EXCLUSIVE

The expression "polish filtration" in (a) above is used in general industrial operation to indicate removal of extremely fine solids from a liquid which to the eye may appear quite clear, or at the most only slightly hazy. Brilliant clarity of the liquid is the result. Over the years, as operators in the petroleum industry have gained experience, the economic advantage of thorough clarification of injection water to the degree of brilliant clarity has become more and more apparent.

Injection Water Filtered

One project in a California field is a good example. Here, pressure filtration using diatomite filteraids has been employed for entire filtration of more than 2,000,000 bbl of injection water over a period of several years. The project is still functioning smoothly with injection of 4000 bbl per day at a pressure of 60 lb per sq in. In contrast, on other injection systems operating in the same area employing sand filters, frequent chemical treatment of the sands is necessary. These wells are operated only at pressure near 400 lb per sq in. How long these wells can be kept operating is questionable.

*Dicalite division, Great Lakes Carbon Corporation, Los Angeles, California.

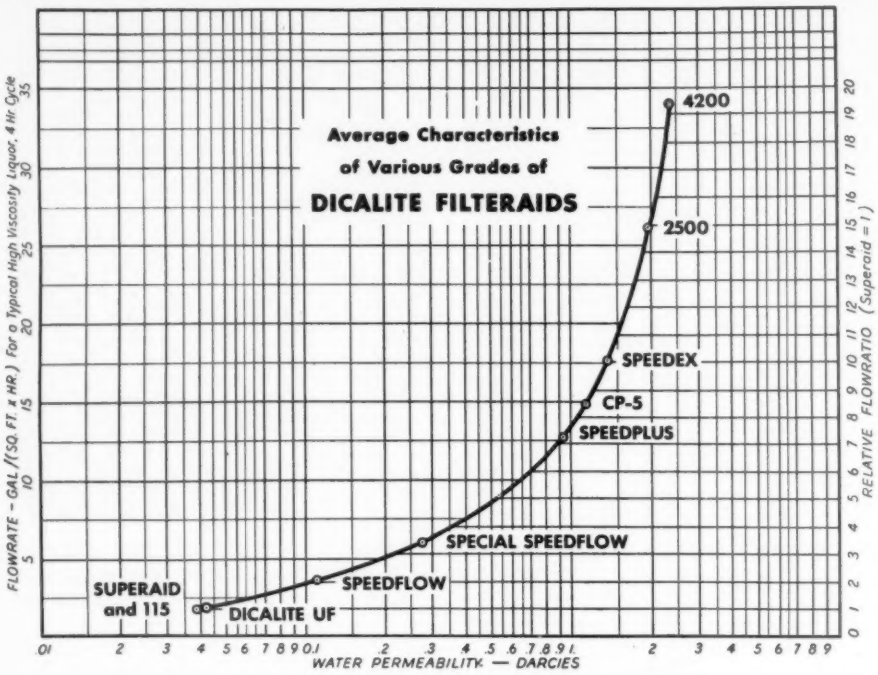

FIG. 2. This chart shows the flow rate (speed) and output capacity of the various grades of diatomite filteraids produced by the Dicalite division, Great Lakes Carbon Corporation. The permeability values of the various grades are helpful in throughput calculations.

Essentially, diatomite filtration consists of microscopic screening or "straining" of solids from the water as it is forced through the layer of filteraid. This filteraid layer is built up on a rigid screen or other type of filter element. The operation starts by forming a precoat of filteraid on the filter element at the rate of about 10 lb per 100 sq ft of surface. Normally, this is followed by a body feed of filteraid added continuously to the water during the filtering cycle.

Surface Is Filtering Medium

It is the surface of this cake of filteraid — not the supporting element — which is the true filtering medium. That is why body feed is usually employed during the operating cycle, since the constant deposition of filteraid particles on the "working" surface of the cake maintains porosity.

At the end of a cycle when a predetermined pressure has been reached, the filteraid cake may be removed from the supporting element by reversing the flow, by internal sluicing, or by opening the filter for mechanical removal of the cake.

Filteraid Processed From Silica

Diatomite filteraids are processed from a non-metallic mineral composed chiefly of amorphous silica—the fossilized remains of diatoms which are single—celled plants related to algae.[5] Millions of years ago—during the Miocene Age—these plants flourished in the waters of the time. A high percentage of silica in the water, due to volcanic action, supplied favorable conditions for growth and multiplication. After a brief life the plants died and settled to the bottom of the water. Their siliceous "skeletons" formed deposits of what are known today as diatomaceous earth, or by the briefer name of diatomite.

Deposits in Western U. S.

The largest and purest deposits of this material are located in the western United States, largely in California, Oregon, Washington, Idaho, and Nevada. The principal deposits in California are of marine origin; those in the remaining states mentioned are of fresh water origin. The latter are geologically newer deposits, some perhaps formed as late as 100,000 years ago.

In Fig. 1 the structure of both the marine and fresh water types is seen with the aid of high microscope magnification. The illustration demonstrates clearly how the "shape factor" of the diatom contributes to the performance of diatomite filteraids.

The crude diatomite is processed into a number of commercial grades of filteraids of varying porosity. Most of the crude is presently mined by open pit quarrying. From that point the processing consists chiefly of crushing, drying, heat treatment, and air separation for removal of non-diatomaceous material and classification by specified particle-size ranges.

The "speed," throughput capacity and permeability (Darcies) of the various grades of diatomite filteraids produced by the Dicalite division of Great Lakes Carbon Corporation are shown in the chart, Fig. 2. The finer filteraids generally give less flowrate but higher clarity. Selection of the particular grade to use should be made according to the individual problem.

Specialized Equipment Developed

Many of the filters used to date in water flooding or disposal work have been those designed for other industrial applications and modified to handle injection water. In some cases this has been satisfactory and in others has not proved practical. Electrolysis and corrosion are the two chief problems. Because of the growing importance of the application, several firms have developed and others are developing specialized equipment for filtration of injection waters.

Special consideration is being given to rubber-lined equipment, use of plastic materials in places, insulation of dissimilar metals, pressed rubber elements and other means of combatting corrosion and erosion. Other points are that the filter should be easy to operate and clean and have a high hydraulic capacity. The majority of the filters now offered for this use consist essentially of a shell or tank in which the elements are suspended, either vertically or horizontally, and which contains the water being filtered.

Mobile System Designed

There are many ideas being developed for convenient and efficient operation of water treatment and injection plants.[6] One system, about to be put into operation in one location in Oklahoma and another in Texas, is unique in being entirely mobile; it is also advanced in the precautions being taken against corrosion.

The equipment consists of a filteraid precoating tank and slurry (body feed) tank with fiber glass linings. The filter tank is monel-lined. The filter leaves are similar to those of a plate and frame press except that they are made of a phenolic resin-impregnated laminated fiber rather than metal. These leaves are covered with a synthetic fiber screen. The pump is of bronze with connections between pump and filter made by means of rubber type flexible hose. Each operating unit of filter, tanks and pump is mounted on skids for easy portability.

Filter elements (supports for the filteraid cake) vary widely both in shape

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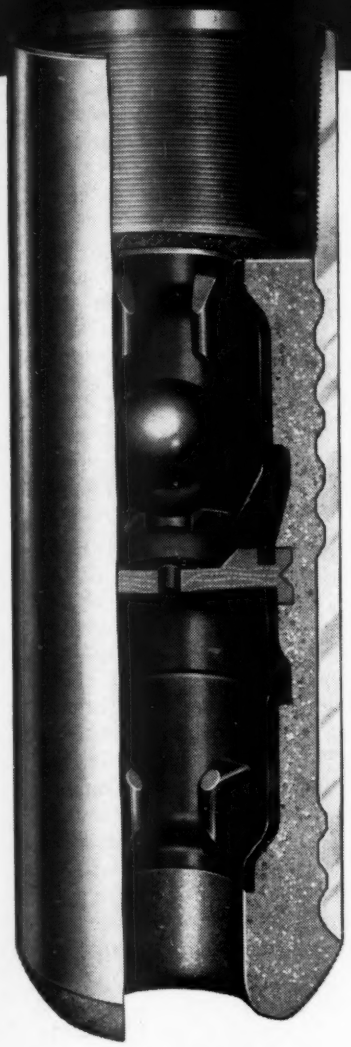

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POSITIVE BALL-TYPE BACK-PRESSURE VALVE FOR CEMENTING

A Ball-Type, Back-Pressure Valve for floating or cementing can be brought into action at any time by applying a pressure of approximately 700 psi to the casing. See Figs. 2 and 3 below.

COMPLETELY DRILLABLE

The internal parts of Flexiflow Fill-Up Shoes and Collars consist of readily drillable concrete, a small amount of Bakelite and synthetic rubber.

ECONOMICAL

Baker Flexiflow Fill-Up Equipment not only permits the casing to be run more rapidly with greatly reduced pressure increases or surges on the formations below the shoe, but in addition, by eliminating the surface-filling operation, saves an additional amount of rig time. When these advantages are considered, Flexiflow Equipment is much more economical to run than conventional floating equipment.

*Pressure surges over 5,000 psi can be created each time a joint of casing equipped with conventional floating equipment is lowered under certain slim hole clearances.

High-Pressure surges can fracture and weaken a formation sufficiently to cause lost circulation or the failure of a primary cement job.

These destructive, high-pressure surges can be reduced . . .

- by increasing the lowering time per joint
- by increasing the casing clearance

or

- by running Baker Flexiflow (or Differential) Fill-Up Shoes and Collars

NOTE:

Baker Fill-Up Equipment contains a variable valve that automatically opens up and adjusts to maintain minimum bottom-hole pressure as the casing is being run.

FIG. 1 Casing Filling while going in the hole

FIG. 2 Ball pumped through diaphragm

FIG. 3 Ball shut-off against cement back-pressure

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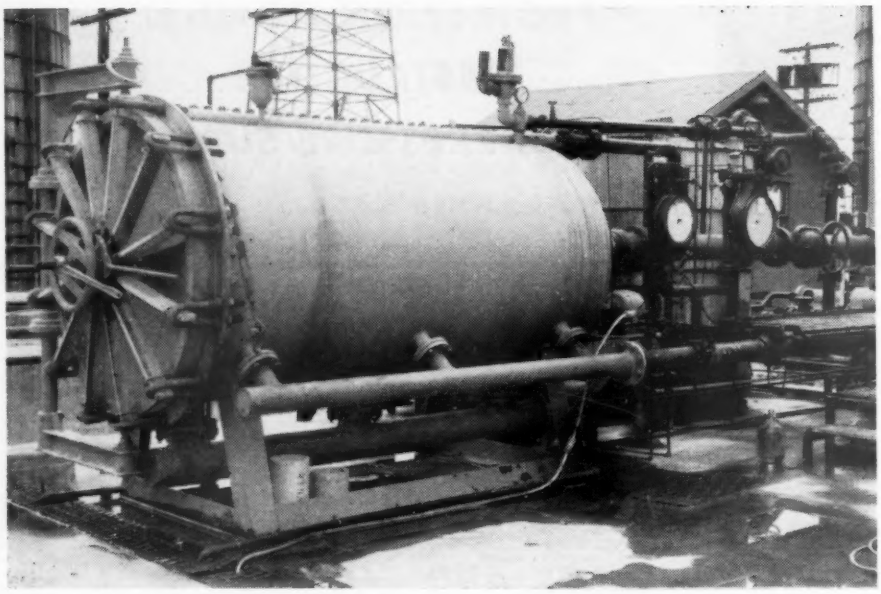

FIG. 3. The filter station for filtering injection water in secondary recovery operation in a California field. This view shows filter and the piping and valve system on the outlet side.

and materials of construction. The most common shapes are circular or rectangular plates, and tubes. Metal screen of sufficiently small mesh to act as the septum are generally employed for the plates. Larger mesh metal screens are in use also, either precoated with the aid of fibrous material such as asbestos, or covered with a cloth or bag of natural or synthetic fiber. The latter has the advantage of high resistance to corrosion.

Metal screen, porous carbon, porous stone, and porous stainless steel are all used for the tubes. Wear and corrosion of metal elements is hard to control. Stone has a tendency to collect precipitated minerals on its surface and thus reduce porosity. This leaves porous carbon as a favored element of this type. The tubular shape offers high surface area for the size of the filter.

Water Key to Filter Choice

Since no two problems are exactly alike, the choice of a particular grade of filteraid should be made after a study of the filtration characteristics of the water involved in each project. Many filter manufacturers have small portable filters which are available for laboratory or field tests. The Dicalite division of Great Lakes Carbon Corporation offers the same service, employing a portable "bomb" filter. The API plugging index test for clarity has been used and, since many petroleum technicians are familiar with the procedure, it can be employed to establish clarity standards.

The simplest problem in this field is the polish filtration of water previously filtered by conventional methods but requiring a higher degree of clarity. The cake space of the filter need not be large. Rates could be expected to vary between one and five gallons per square foot of filtering surface per minute.

As the water is relatively clear, a precoat of a general purpose filteraid such as Dicalite Speedplus* should suffice. Cycle lengths will average around five days. In those cases where it is proposed to remove a finely divided colloidal suspension of a clay such as bentonite a finer filteraid should be chosen. In this case, the rate will generally approximate one gallon per square foot per minute.

For the direct sole filtration of water for injection it is necessary to consider the problem in two phases, one for fresh water and one for salt.

Fresh water from a sub-surface source can usually be readily handled. An excellent example of this type exists in a West Texas location where roughly 4000 bbl per day of fresh water are filtered on 160 sq ft of filtering area. The water is settled, then treated with chlorine to a residual of 0.35 ppm. Sodium tetra phosphate is added ahead of the filters at the rate of 1.4 lb per 1000 bbl.

As the cycle is started, a precoat of 16 lb of Speedplus is used. This conforms to the standard precoat recommendation mentioned earlier of 10 lb per 100 sq ft of filter area. About 2 lb of filteraid is added as body feed to 1000 bbl of water. The initial pressure differential on the filter is 10 psi and the cycle ends when 30 psi is reached which is about 10 days. This particular raw water contains approximately 25 ppm total undissolved solids.

Although as previously mentioned, and it should be emphasized, each water should be studied as a separate problem, sufficient data are on record for sub-surface fresh water to indicate flows between the limits of 1-3 gal per square foot per minute accompanied by cycle lengths from 1 to 10 days to be expected. Essentially, all undissolved solids can be removed as well as the great majority of bacteria.

For handling fresh water from surface sources the problem is more complex. The filterability of the water will vary widely both with the source and season of the year. On this problem pressure filtration with diatomaceous earth is more advantageous for small volumes. The best procedure is to test the water for filterability and response to other treatment under its various conditions.

Salt water filtration has been developed largely in California. A number of units are operating successfully with purposes varying from direct flooding to simple disposal of excess water. There are studies being made, in addition, to avert the subsidence of land by maintaining subsurface pressure. Whatever the purpose, the problem varies only in the degree of clarity required. Each operator has developed a standard of clarity consistent with the type of subsurface sands into which he injects the filtered water.

The majority of water treating plants in California use diatomite filters. Of 18 projects surveyed it was found that 11 of these filtered the water with diatomite. Operation is essentially the same as when dealing with fresh water.

As would be expected, the principal problem is corrosion of the filter parts, piping, pumps, and other equipment, and the same precautions and preventative measures as previously discussed are employed. Shells (tanks) of the filters are usually rubber or plastic-lined and the filter leaves or other supporting elements are made of saran or other plastic, stainless steel, and often monel metal.

Salt Water Systems

Three types of systems are employed: open, semi-closed, and closed. If it can be employed, the latter has the important advantage of eliminating dissolved oxygen. This system also minimizes entrance of air-borne bacteria (algae of various types), which aggravate the corrosion problem because of sulfate reduction in addition to increasing the load on the filter in removing the bacteria.

The semi-closed system and open systems are essentially polish filtration

*Dicalite and Speedplus, Reg. U. S. Pat. Off.

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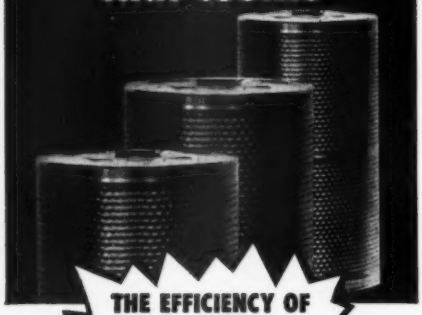

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operations. Prior to filtration there may be flocculation, settling, flotation and skimming, or sand filtration. Chlorine or other bactericides are used to control growth of algae and bacteria, and scale-preventing compounds such as phosphates are often added before filtration. In these cases diatomite filteraid in varying amounts from 0.01 to 0.04 lb per barrel are added as body feed in addition to the precoat. Normal operating flowrates of 0.3 to 0.6 gal per minute per square foot of filtering area are obtained with cycles up to 5 days.

One typical installation filters 15,000 bbl per day on 2 filters at different locations. The filters are the horizontal type, having vertically suspended leaves. All water filtered is subsurface water except for 1000 bbl per day which comes from the gas plant. This gas plant water contains 15,000 ppm of sulfates. Prior to filtration all water is skimmed in ponds, 500 bbl of oil per month being recovered in this way.

Currently, the water is treated rather heavily with formaldehyde early enough in the system so that the full effect is felt before filtration. This has proved very effective in securing smooth operation; up to 48-hour cycles are now secured whereas before this type of treatment was employed the maximum was only 16-hour cycles.

As is well known, water is not the simple liquid it seems. The whole subject of treatment, including filtration, to secure water that will not plug underground formations is quite complex. A great deal of work has been done by oil companies, filteraid and filter manufacturers, and suppliers of equipment. In filtration, specifically with diatomite filteraids, the process has proved economically practical and has exclusive advantages.

The Dicalite Division of Great Lakes Carbon Corporation has for some years been running pilot test work in both the laboratory and the field. It is planned that the results of this work can be made the subject of future articles.

Bibliography

1. J. Kenneth Fraser, Diatomaceous-Earth Filtration in New York State, Journal American Waterworks Assn., February, 1954.
2. E. Robert Baumann and Harold E. Babbitt, Use of Diatomite Filters Can Be Economical, *Water Works Engineering*, June, 1953.
3. G. G. Halvorsen, Paper Mill Effluent Control Using Filtration with Diatomaceous Filteraids, Tappi, April, 1952.
4. Anonymous, Filtration Unit in Operation at Humble's Baytown Refinery, *Oil and Gas Journal*, July 21, 1952.
5. Wm. Q. Hull, H. E. Keel, J. J. Kenney, Jr., B. W. Gamson, Diatomaceous Earth, Industrial & Engineering Chemistry, February, 1953.
6. J. Wade Watkins, F. R. Willett, Jr., Charles E. Arthur, Conditioning Water for Secondary Recovery, *The Petroleum Engineer*, May, 1953.

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Part 2 of a Series

waterflooding activities in the KMA field

R. P. Dobyns,*
C. T. Burchett, Jr.,*
D. S. McBride,†
and R. R. Darner‡

THE history before waterflooding for the W. H. Hammon and Warren Petroleum Corporation, Hammon project was given in Part I of this series. The leases included in this project are the Hammon and Warren Fassett and Tuttle "A" lease, Warren's Fassett & Tuttle "B" lease and Warren's Hammon lease. Together they comprise a productive area of 1568 acres from which 2,878,-761 bbl of oil were produced prior to water injection.

Operators here were confronted with bypassing difficulties in the gas injection project prior to introduction of water injection. Time has proved this to be one of the most successful KMA projects, with a net waterflood oil recovery (as of January 1, 1954) of 71,-900 bbl or a volume increase of 217 bbl per flood-pattern acre. Five out of the 15 producing wells had responded to the injection to that date.

Development of Waterflood

This waterflooding project has been under continuous expansion since Fassett & Tuttle "A" well No. 18 was converted to a salt water injection well during June, 1950. Producing wells were converted to water-injection wells as follows: In September, 1950, Hammon wells No. 3 and 5; in August, 1951, Fassett &Tuttle "A" well No. 16; in January, 1952, Fassett & Tuttle "A" well No. 33; and in January, 1953, Fassett & Tuttle "A" well No. 41. On January 1, 1954, the flood pattern area contained 332 acres, as shown in Fig. 4, where the area is enclosed by the hachured line connecting the outermost line of oil wells surrounding the water-input wells. The flood pattern area has 6 water-input and 15 producing wells. The gross volume of the reservoir rock is 15,720 acre-ft and the average gross thickness 47.3 ft.

When waterflooding was begun, all of the wells took the water under a vacuum. Since then the pressures have gradually increased and on January 1, 1954, ranged from 150 to 350 psi. The volume of water injected per month has varied considerably (see Fig 6), mainly because the source of injection water was inadequate. The cumulative injected water-produced oil ratio was 4.4, and the average volume of water injected per injection well per day per ft of gross sand thickness was 3.8 bbl. The estimated cumulative water produced was 9368 bbl, based on daily tests on the producing wells.

During the entire time the waterflood has been in operation, gas has been injected into all of the gas-injection wells shown in Fig. 4 for the leases in the project.

Method of Completing and Operating Wells

All of the producing and water injection wells were completed with 7-in. casing set and cemented near the top of the producing zone, and most of the wells have been shot with nitroglycerin. None of the producing wells were reworked or recompleted when waterflooding was begun.

The water-injection wells are converted oil wells. No special completion techniques were used. The tubing was removed from the producing wells when they were converted.

The producing wells in the flood-pattern area, equipped with intermitters, were flowed until the wells began to respond to the injected water. It then became necessary to pump the wells, and standard pumping equipment is now used. The time at which it became necessary to start pumping the producing wells that have responded to waterflooding is shown in Fig. 7.

EXCLUSIVE

Source and Treatment of Injected Water

The injected water for this project is obtained from shallow Cisco series sand, ranging in depth from 1200 to 2400 ft. To obtain an adequate supply of water from these sands, three wells were drilled and completed with water sands exposed to the well bore at depths of 1200, 1300, 1800, 1900, and 2400 ft. A schematic diagram of the closed-type water-injection system is shown in Fig. 8. The water is pumped directly from the three water-supply wells through a 3-in. supply line to 5000 bbl steel settling tank. An oil seal is maintained on top of the water in the settling tank to exclude the air from the water. Water is pumped from the settling tank to the meter manifold by a Gaso duplex pump powered by a Chrysler gas engine. The water-injection pump is connected to the meter header with a 4-in. line, and 2-in. lateral supply lines connect the meter header to the individual input wells. The water meters are 1-in., piston-type, Pittsburgh meters; screens and strainers are ahead of the meters. No corrosion difficulties have been experienced. An analysis of injection water for this project showed that the water had zero turbidity and that the produced water and the injection water were compatible in that they did not form an insoluble precipitate on mixing. However, none of the produced water is being reinjected at this time.

Results of Waterflooding

Fig. 6 shows graphically the production and injection history of all leases in the project. From extrapolation of the production-decline curve, it was estimated that 71,900 bbl of net waterflood oil was recovered from this project to January 1, 1954. This volume of oil represents a recovery of 217 bbl per flood-pattern acre of 45.8 bbl per lease acre. It should be noted that all of the water-injection wells have

*Bureau of Mines, Wichita Falls, Texas.
†Tide Water Associated Oil Company, Kamay, Texas.
‡W. H. Hammon, Wichita Falls, Texas.

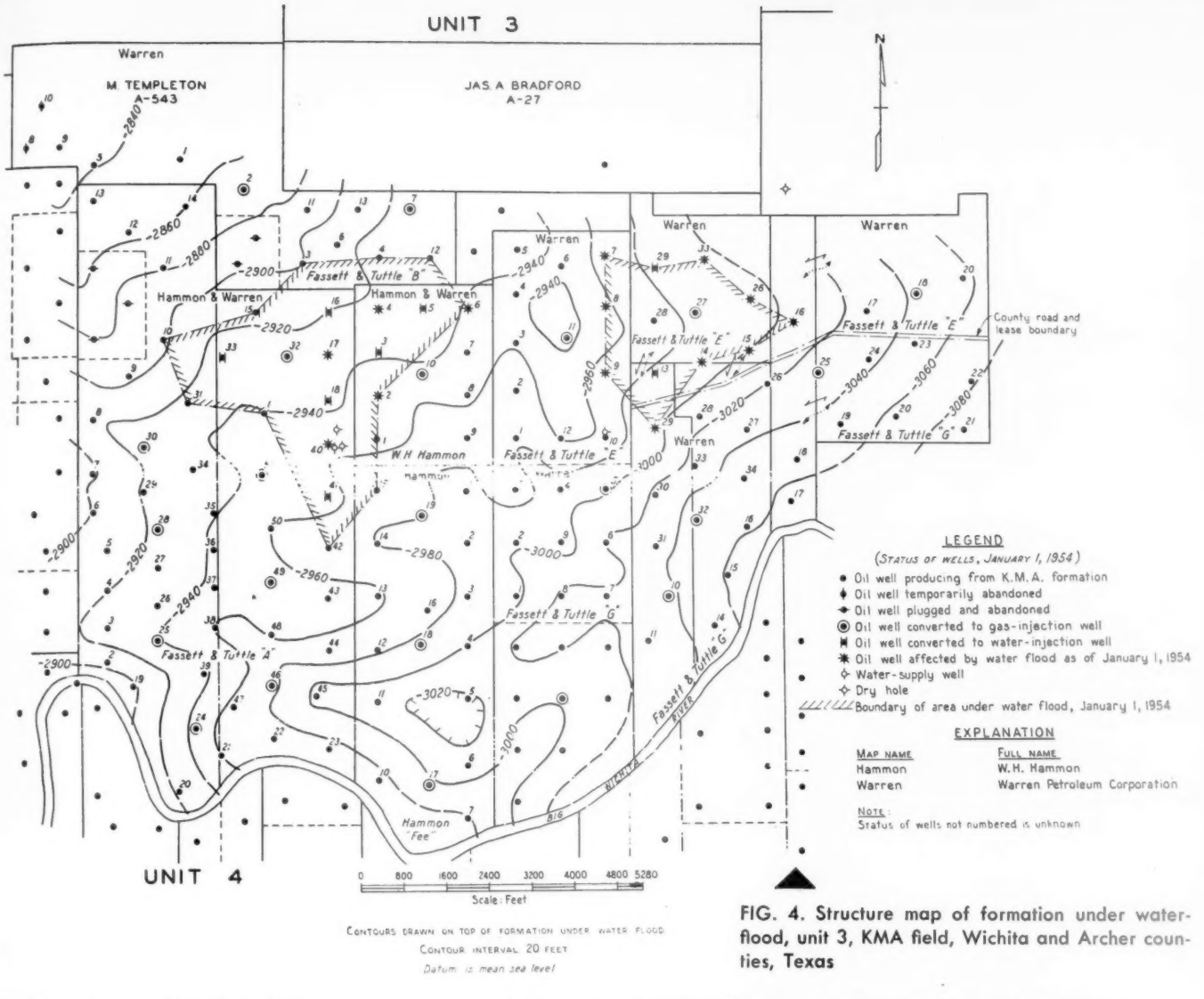

FIG. 4. Structure map of formation under waterflood, unit 3, KMA field, Wichita and Archer counties, Texas

not been in operation the full life of the project. Table 1 lists pertinent reservoir volume, oil-production, and water-injection data for this project.

Fig. 4 shows the relative positions of the oil wells that have been affected by the waterflood to January 1, 1954, and Fig. 7 shows graphically the production histories of these oil wells. Only one producing well, Hammon No. 4, has shown any water production, and during December, 1953, the average daily production was 42.5 bbl of oil and 27.5 bbl of water. As shown in Fig. 7, the producing wells affected by two water-input wells were producing approximately half as much oil as the wells affected by three water-input wells.

The first well responded to water injection approximately 17 months after injection was begun. Production data show that only 9368 bbl of the 988,760 bbl of water injected has been produced since flooding was begun.

The results obtained with this pilot flood indicate that the project should be expanded into a full-scale waterflooding operation.

Warren Petroleum Corporation Fassett & Tuttle Project

The Warren Petroleum Corporation Fassett & Tuttle waterflooding project includes the Fassett & Tuttle "E" lease and one well that has responded to water injection on the Fassett & Tuttle "G" lease. The Fassett & Tuttle "E" lease is in the S.A. & M.G. survey, abstract 267; the R. E. Huff survey, abstract 582; the R. Brown survey, abstract 523; and the B.S. & F. survey, abstract 740. Well No. 29 on the Fassett & Tuttle "G" lease is in the J. Wisdom survey, abstract 572.

History Before Waterflooding

The following discussion pertains only to the Fassett & Tuttle "E" lease, which contains 603 productive acres. However, it is estimated that 4.6 acres around well No. 29 in the Fassett & Tuttle "G" lease are affected by the flood.

The productive formation being waterflooded is considered to be Zone II. The gross productive volume of Zone II of the Fassett & Tuttle "E" lease is 25,015 acre-ft and the average gross thickness 41.5 ft.

At the time waterflooding was begun, 1,104,720 bbl of oil had been recovered from the "E" lease, a recovery of 1832 bbl per acre.

It is estimated that only 12.5 per cent of the initial volume of stock-tank oil in place in the reservoir had been recovered from the Fassett & Tuttle "E" lease when waterflooding was begun in December, 1950. Table 1 gives pertinent information concerning the oil recovery from this lease before waterflooding was initiated. The production history of the lease is shown graphically in Fig. 10. The average daily oil production when waterflooding was begun was approximately 100 bbl.

Structure maps contoured on top of the KMA limestone and on top of the producing formation are given as Fig. 3 and 4, respectively. In this area, the dip of the producing formation is southeastward at a slope of approximately 100 ft per mile.

An isopachous map of the gross thickness of the producing formation is shown in Fig. 5. The formation in this

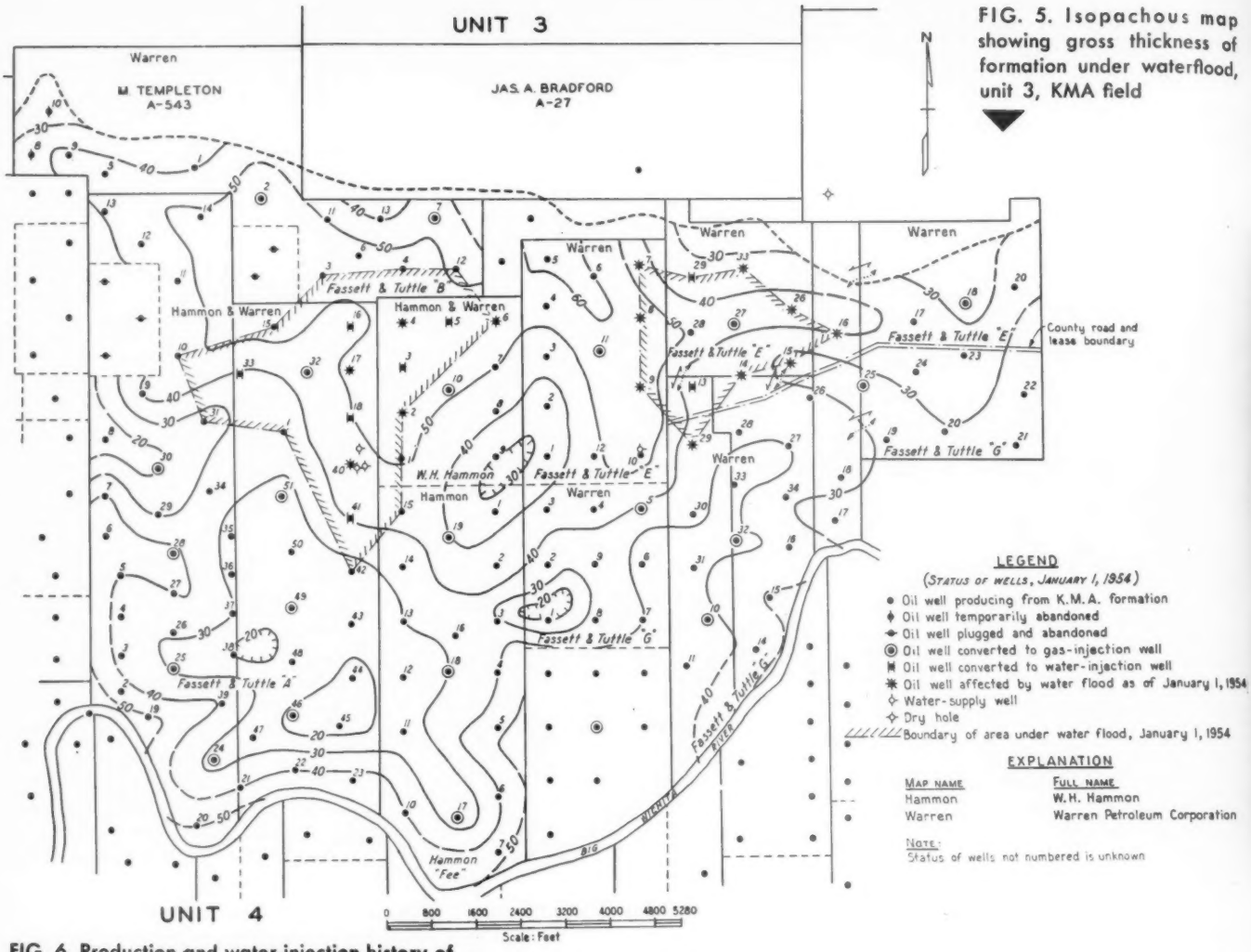

FIG. 5. Isopachous map showing gross thickness of formation under waterflood, unit 3, KMA field

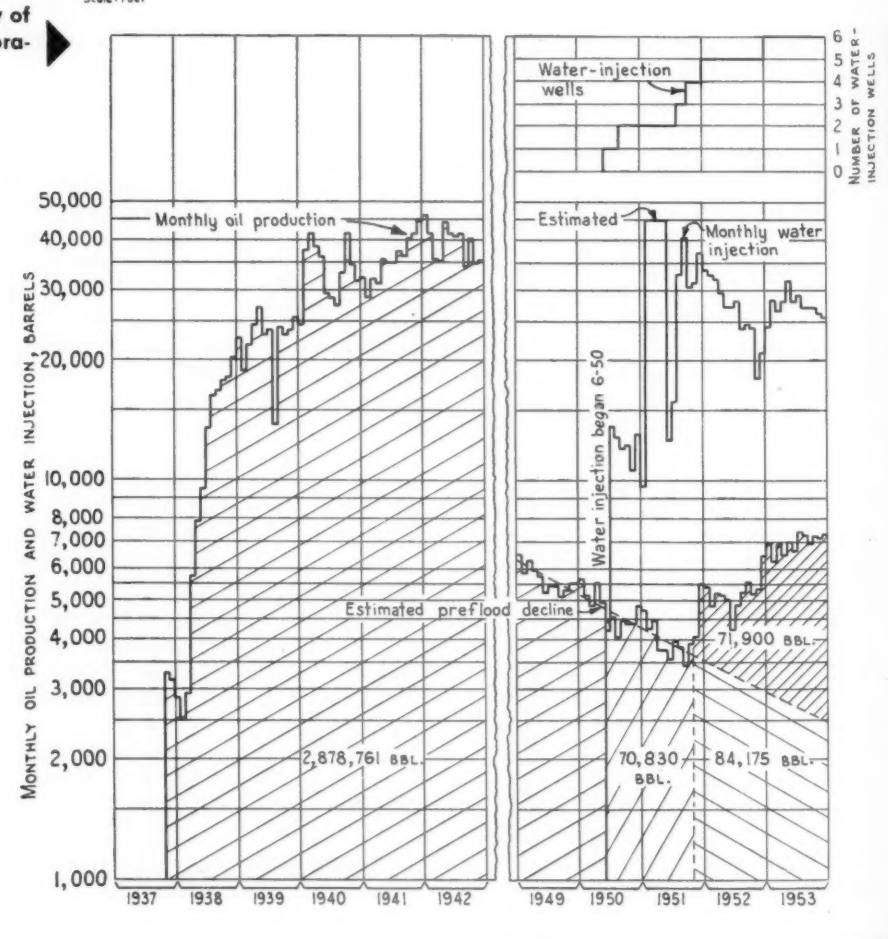

FIG. 6. Production and water-injection history of W. H. Hammon and Warren Petroleum Corporation Hammon project, unit 3, KMA field

area thickens to the northwest.

Development of the Fassett & Tuttle "E" lease was begun in October, 1939, and was completed in January, 1942. The producing wells were completed with either 5½ or 7-in. casing set and cemented near the top of the producing formation. All wells, except No. 10, were shot with nitroglycerin. Most of them were drilled through the producing section and a few feet into the underlying shale. However, on completion the hole was plugged back to the bottom of the producing formation.

This area in the vicinity of the waterflood had been subjected to extensive gas repressuring before the project was initiated. The Fassett & Tuttle "E" lease has three gas-injection wells currently in operation, as shown in Fig. 4. One of these, well No. 27, is in the middle of the waterflood pattern. The Fassett & Tuttle "G" lease, which has been subjected to extensive gas repressuring during the past several years, has four active gas-injection wells.

Development of Waterflood

The injection of brine into Fassett & Tuttle "E" wells No. 13 and 29 was

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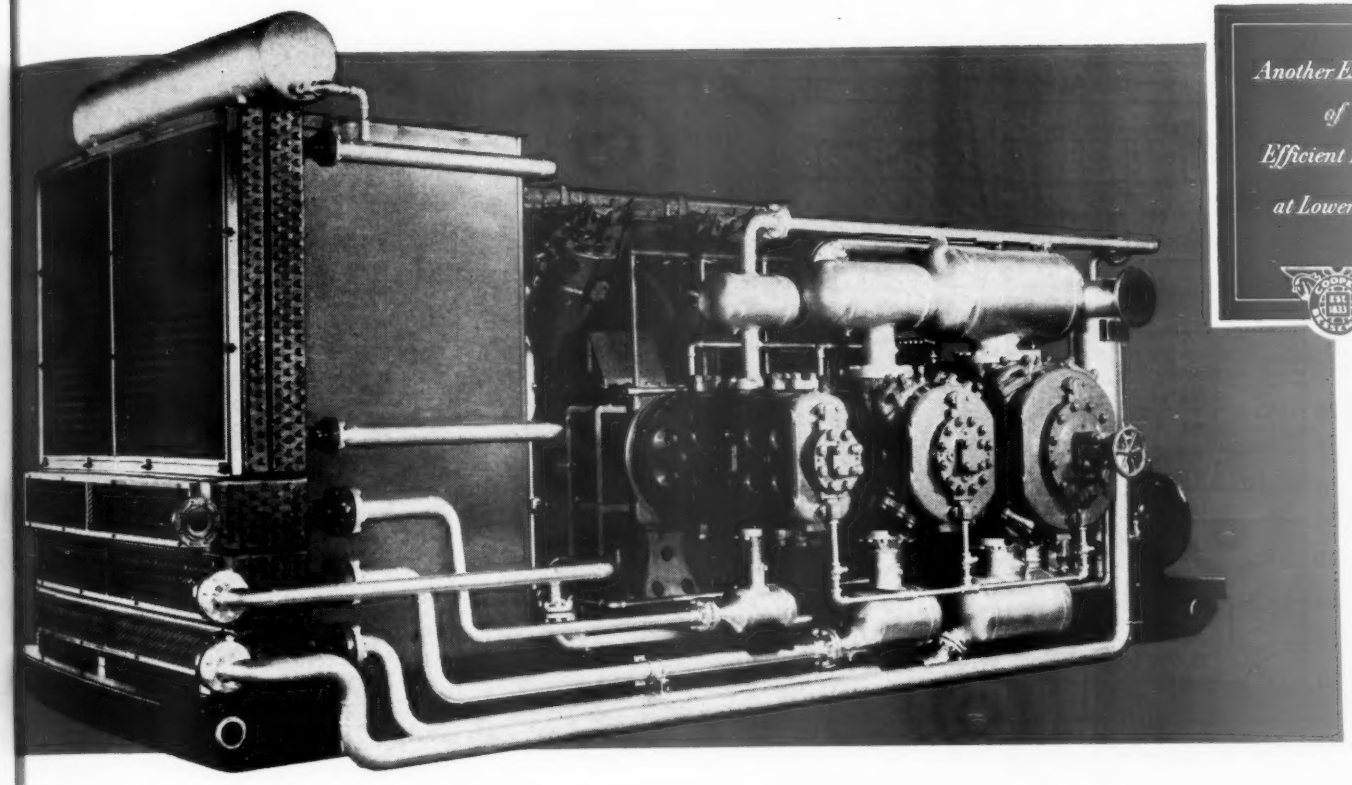

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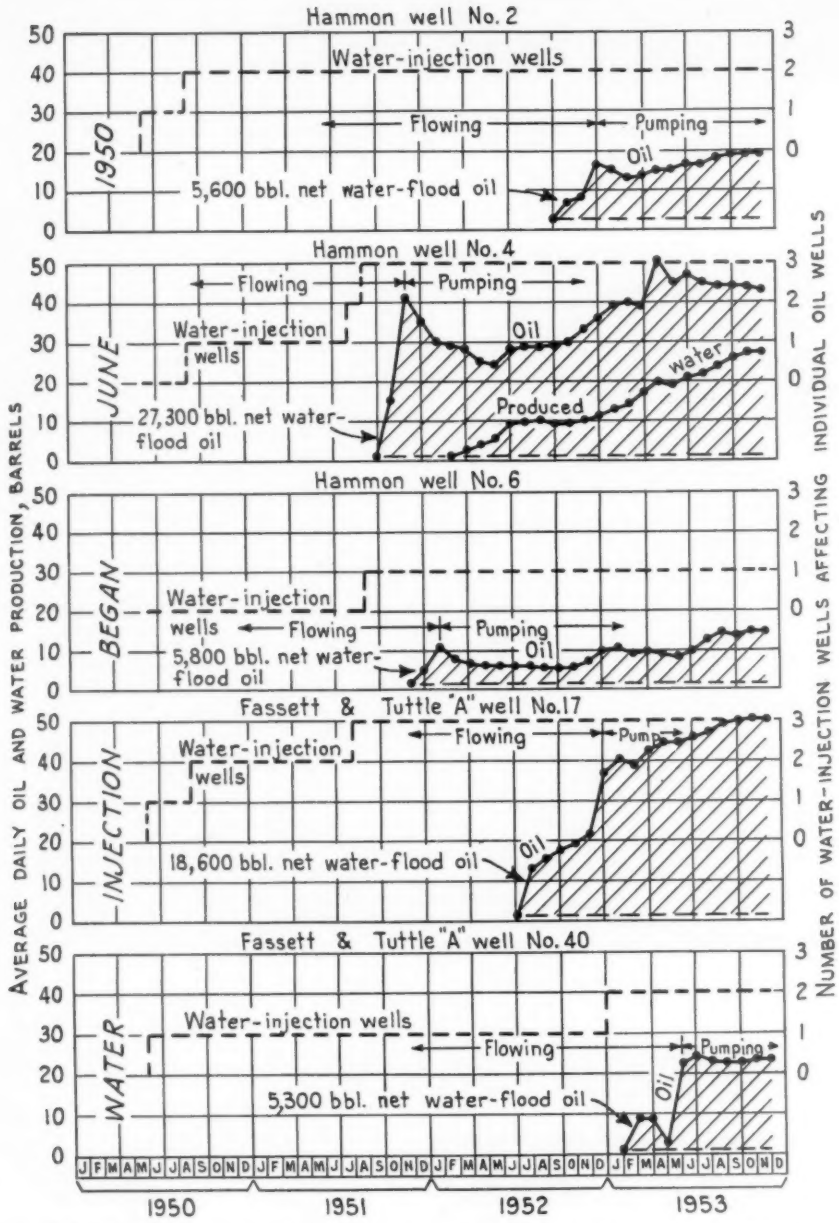

FIG. 7. Production performance of wells in flood pattern, W. H. Hammon and Warren Petroleum Corporation Hammon project, unit 3, KMA field

begun in December, 1950. Fig. 5 shows the flood pattern, which covers a productive area of 144 acres. The underlying reservoir has a gross volume of 6020 acre-ft and an average gross thickness of 41.8 ft. One gas-injection, 10 producing, and 2 water-input wells are included in the flood-pattern area.

The volume of water injected per month is graphed in Fig. 10. Because of difficulties with the pumping equipment, the volume of water available for injection has been erratic; as a result, the quantity injected each month has varied considerably. At the start of waterflooding, water was injected under a vacuum at the wellhead; but in December, 1953, a wellhead pressure ranging from 512 to 587 psi was necessary for injection. To January 1, 1954, the average volume of water injected per well per day per ft of gross thickness was 10.1 bbl. The ratio of cumulative water injected to produced oil, as of January 1, 1954, was 5.9. Additional pertinent waterflood data are given in Table 1.

Completing and Operating Wells

No remedial work was done on the producing wells in the flood-pattern area before water-flooding was initiated. Normally, pumping equipment was installed when a producing well responded to water injection. Fassett & Tuttle "E" well No. 9 is the exception and has continued to flow, with the use of an intermitter, even though the well has shown increased oil production as a result of water injection. Wells that were converted to pumping were equipped with standard pumping equipment and jacks, powered by gas engines.

The tubing left in the wells is used for injecting water into the formation. The water-input wells were not reworked when converted for injection purposes. However, the wells later were cleaned out, and one well was acidized in an unsuccessful attempt to increase the water-input rate.

The water-supply well is equipped with a standard pumping jack and a subsurface casing pump. Because of considerable trouble with broken sucker rods, the water-supply well has frequently been inoperative.

Injection Water

The water for injection is obtained from a well completed in the Cisco series water sands at depths of 2318 to 2351 ft and 2405 to 2434 ft. A chemical analysis of the injection water follows:

Radical	Ppm
Sodium (Na)	47,000
Calcium (Ca)	11,580
Magnesium (Mg)	1,990
Undersaturated, 2 ppm as $CaCO_3$	
Chloride (Cl)	98,700
Sulfate (SO_4)	8
Bicarbonate (HCO_3)	50
Total iron	70

Indicated pH, 6.0
Specific gravity, 1.130 at 60 F.

The water is pumped from the supply well through 3-in. line pipe directly into the first of two wooden, 350-bbl, water-storage tanks. As the water is not treated and the system is of the closed

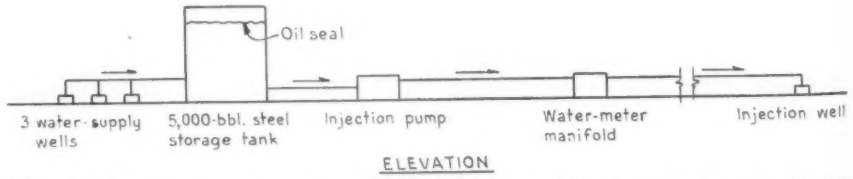

FIG. 8. Flow diagram of water-conditioning system, W. H. Hammon and Warren Petroleum Corporation Hammon project, unit 3, KMA field

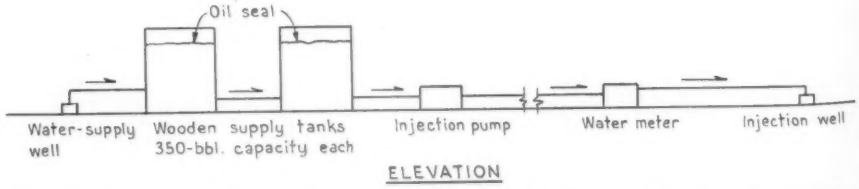

FIG. 9. Flow diagram of water-conditioning system, Warren Petroleum Corporation Fassett and Tuttle project, unit 3, KMA field

type, an oil seal is maintained on top of the water in the two water-storage tanks to exclude air. The water flows by gravity from the storage tanks to the water-injection pump, which is a Gaso duplex powered by a Chrysler engine. The water flows from the injection pump through 2-in. upset tubing to the two injection wells. The volume of water injected into each well is measured by a 1-in. Pittsburgh meter.

A schematic diagram of the closed-type water-injection system is shown in Fig. 9. To date, the operators have not been troubled with corrosion problems. Although a mixing of the injected and produced waters did not indicate that an insoluble precipitate would result, the steady increase in injection pressures may be indicative of some plugging action within the pores of the formation rock, as it is doubtful that fill-up is being obtained with only two injection wells.

Results of Waterflooding

Pertinent data concerning results of this waterflooding project are given in Table 1. The production and water-injection history of the Fassett & Tuttle "E" lease is shown graphically in Fig. 10; the performance of the producing wells in the flood-pattern area is shown graphically in Fig. 11.

From the time waterflooding was begun in December, 1950, to January 1, 1954, injection of 753,869 bbl of water resulted in production of 42,900 bbl of net waterflood oil. To January 1, 1954, Fassett & Tuttle "G" well No. 29 had produced approximately 2200 bbl of this net waterflood oil. This volume of oil represents a recovery of 298 bbl per acre in the flood-pattern area or 70.6 bbl per lease acre. During December, 1953, 51.5 per cent of the total oil production from the Fassett & Tuttle "E" lease was net waterflood oil, and from the time the project began to respond to water injection to January 1, 1954, 35.7 per cent of the total oil production was net waterflood oil.

The individual well performance graph (Fig. 11) shows that well No. 28 on the Fassett & Tuttle "E" lease, which is directly between the two injection wells, has not responded to the water injection. This well has continued to flow and maintain approximately the same rate of oil production it had at the beginning of the waterflood. The gas-oil ratio curve is declining, however.

This may indicate an increase in oil production in the near future, as other individual well-performance gas-oil ratio curves show that gas-oil ratios definitely declined either immediately before or at about the same time of the increase in oil production. Fassett & Tuttle "E" well No. 14 is

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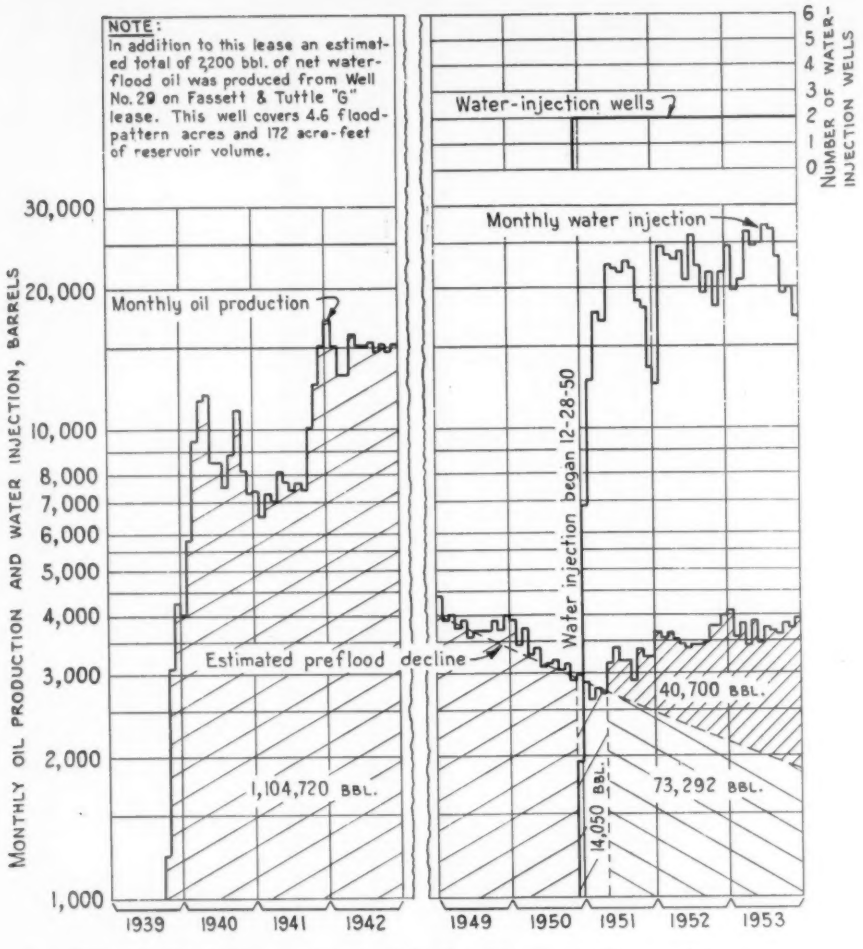
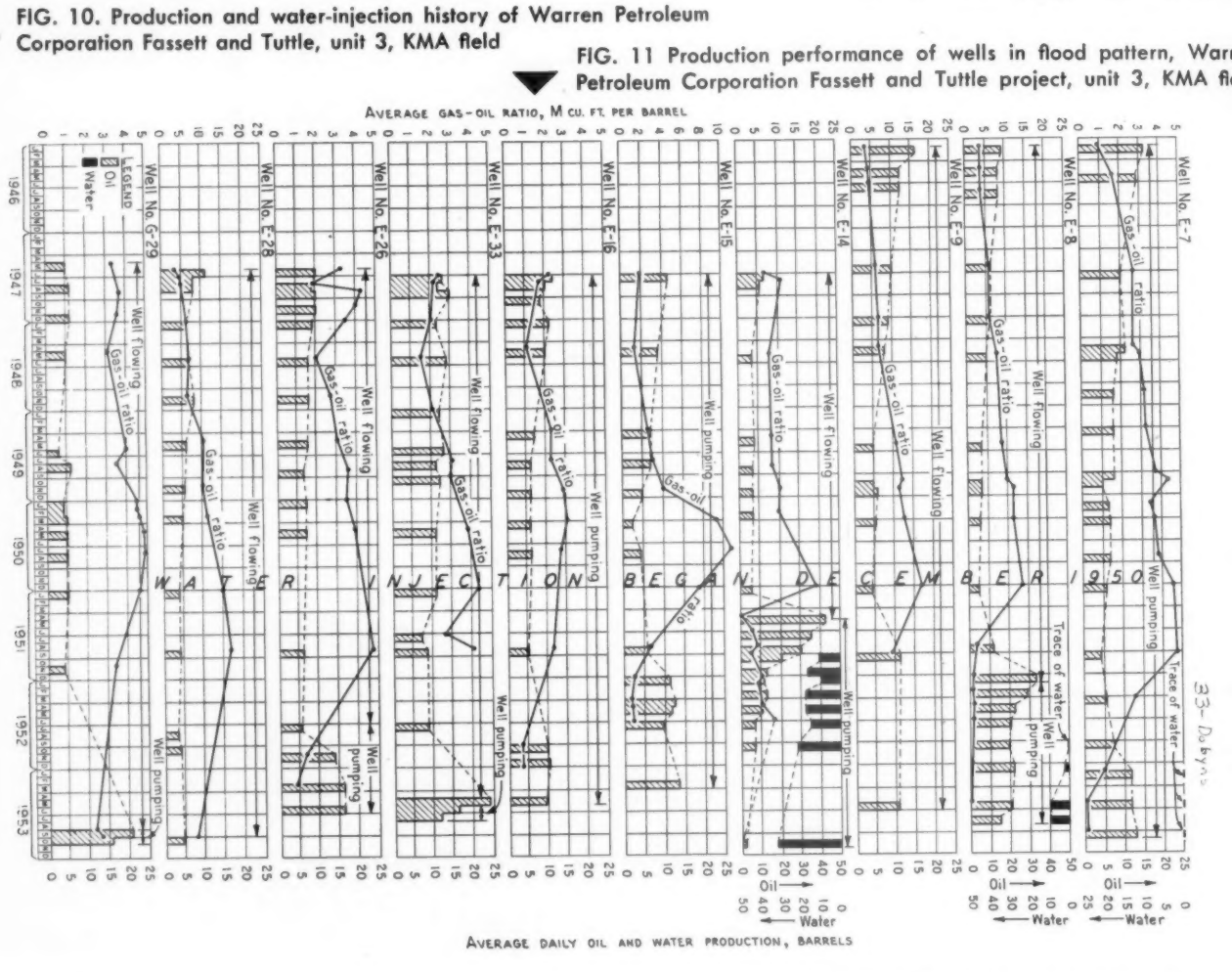


FIG. 10. Production and water-injection history of Warren Petroleum Corporation Fassett and Tuttle, unit 3, KMA field

the only well in the pilotflood area that has shown a large increase in water production with a decline in oil production after the peak oil-production rate has been reached. Peculiarly, the gas-oil ratio of this well began to increase with the decrease in oil production and the increase in water production. However, the gas-oil ratio again decreased to an immeasurable value during the latter part of December, 1953, when the volume of oil produced was very small. Wells No. 7 and 8 on the Fassett & Tuttle "E" lease have shown some water production. Wells No. 7, 8, and 14 are in a general east or west direction from the two water-injection wells. The fact that well No. 28 has not responded to water injection and that Fassett & Tuttle "G" well No. 29 only responded in the last quarter of 1953 indicates that the injected water is moving east-west.

Gas-oil ratio histories of wells surrounding the gas-injection wells of these leases also indicate an easier movement of the gas east-west. The isopachous map of the producing formation (Fig. 5) shows that the maximum sand thickness trend is east-west along the north part of these leases and that the formation thins to the north and south. These conditions indicate that there is directional permeability in the sand body; this should be

FIG. 11 Production performance of wells in flood pattern, Warren Petroleum Corporation Fassett and Tuttle project, unit 3, KMA field



thoroughly investigated before the pilot floods in Unit 3 are expanded. In another section of this report, entitled "Results of Directional Permeability Tests," the tests of core samples obtained from wells in Unit 6 in the southwestern part of the KMA field are discussed.

A total of 56,471 bbl of water was injected during the five-month period from the initial injection of water to the first response to the injected water. Nine of the producing wells have been affected by the waterflood to January 1, 1954.

The results of this pilot flood indicate that this area of Unit 3 should respond favorably to a comprehensive waterflood.

Unit 5 Waterfloods

In April, 1951, waterflooding was begun in Unit 5, when LeBus Oil Company began injecting water into its Mangold well No. 22. Since that time, four other pilot waterflooding projects have been started in this unit. As of January 1, 1954, three projects were in operation, and two were abandoned. The location and status of these projects are shown in Fig. 1.

Bureau of Mines Report of Investigations 4892[1] pertains to Unit 5 and 6 and contains details regarding the geology, past reservoir performance, and physical characteristics of the reservoir rock and fluids. This report also presents an evaluation of the gas pressure-maintenance program and the possibilities of waterflooding the reservoir on the basis of the theoretical calculations. A brief summary of pertinent data from this report is repeated here on the physical characteristics of the reservoir and fluids.

The average porosity is 16.5 per cent for Zone I and 16.1 per cent for Zone II. The average permeability is 84 md for Zone I and 216 md for Zone II. The estimated connate-water saturation is 17.5 per cent for Zone I and 20.0 per cent for Zone II. The initial reservoir pressure was 1750 psi, although the reservoir oil, being undersaturated, had a saturation pressure of 1300 psi; at this pressure, a barrel of stock-tank oil contained 525 cu ft of gas in solution. The initial formation-volume factor was 1.304.

The injection of produced gas into the reservoir was begun on a large scale in January, 1940. The gas-injection program still is in operation. During December, 1953, approximately 12.3 per cent of the gas produced from Unit 5 was returned to the reservoir. This is equivalent to 297 cu ft per bbl of oil produced from the unit.

(To Be Continued in June)

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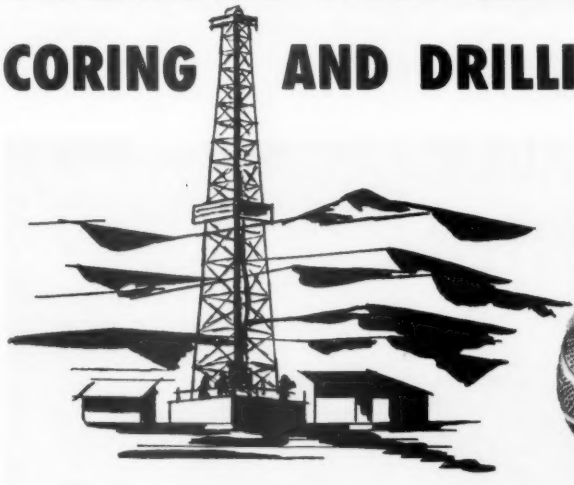

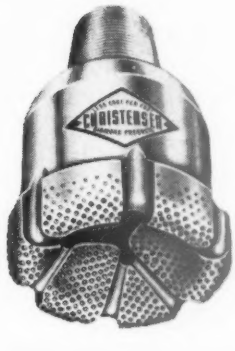

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WILDCAT FIELD, LINCOLN COUNTY, LOUISIANA							
Travis Peak 8⅝"x5¼" Core Bit	725 ft.	3 ft./hr.	$2145.30	**$2.96**	8,000-16,000	50-60	275 gpm
QUALEY DOME FIELD, ALBANY COUNTY, WYOMING							
Red Beds 6-3/16" Drilling Bit	638 ft.	2 to 3 ft./hr.	$ 846.05	**$1.33**	5,000-12,000	70	230 gpm
WERTZ FIELD, CARBON COUNTY, WYOMING							
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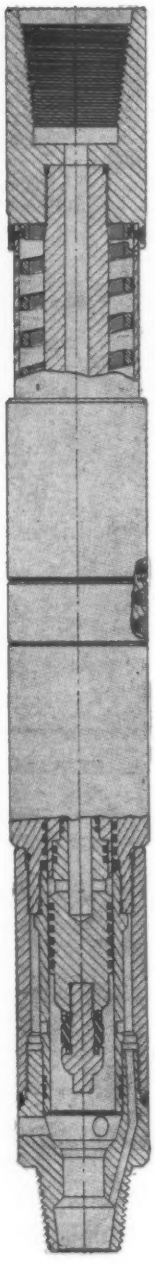

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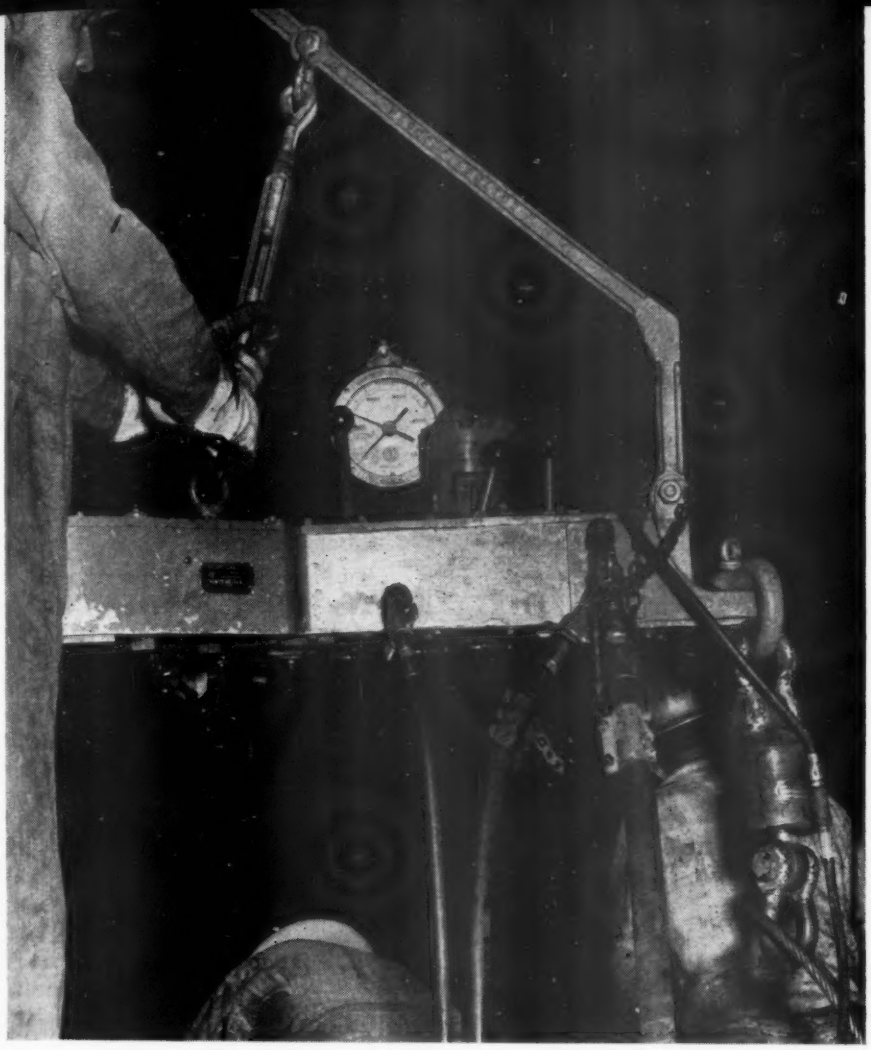


New hydraulic casing tong is compact and lightweight for ease of handling. Note torque gage mounted on top of tong, center, and hydraulic load cell, lower right, with upper line leading to gage and lower line leading to strip chart recorder.

P 420

New casing tool offers speed and versatility. Torque recorder supplies operator with strip chart record of casing job

Jerry Stumm
Editor, Pacific Coast

ENGINEERS and manufacturers have been continuously developing and improving means by which pipe can be run in and out of a well without the hazardous and time consuming use of spinning rope and spinning chain since about the mid-1930's.

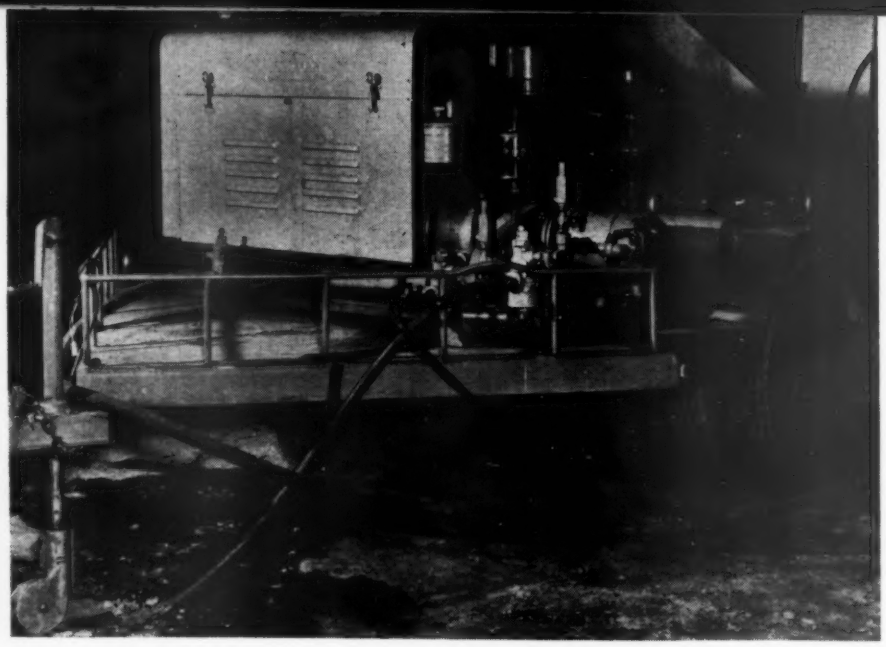
The first power tongs to receive commercial acceptance were pneumatic tubing tongs. These became so popular and widely accepted that it was not long before the same principle (the use of air as a driving force) was applied to the development of drill pipe, casing, and even sucker rod tongs.

Continued demand for faster, more powerful and smoother operating tongs soon turned the eyes of engineers and manufacturers toward the application of hydraulics as a driving force. The first hydraulic tubing tongs appeared only recently and have already proved to possess all of the advantages heretofore mentioned. Still more recently a hydraulic casing tong was introduced which seems to be gaining fast acceptance in all major oil fields.

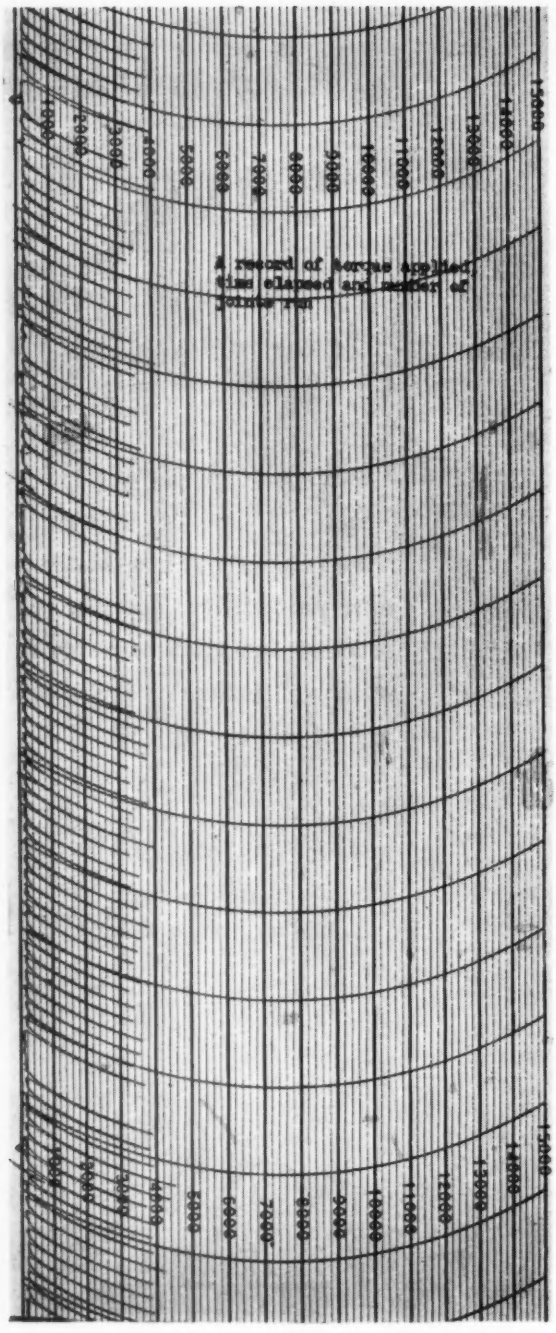
This new hydraulic casing tong is able to handle from 4¾-in. OD through 11¾-in. OD pipe by the use of quick interchanging jaws and bushings, yet is remarkably light in weight (only 775 lb). It seems to have far more than adequate strength for the torque requirements of normal casing jobs, however. In fact, through the additional torque that has been gained by the application of hydraulic drive, it is proving to be an excellent tool for the salvaging of old casing. On a recent back-out job in Ventura, California, the tong was employed to salvage casing that had been set in a well for 31 years.* The average running time on this job, breaking out 20-ft joints of 6⅝-in. and 8¼-in. casing was 27 joints per hour. For back-out work the tong has a 12,000 ft-lb torque capacity with a 2 to 1 safety overload. Shock loads on this and other back-out jobs have been registered in excess of 20,000 ft-lb torque, however.

**The Petroleum Engineer,* November 1954, page E-26.

EXCLUSIVE



Hydraulic power unit may be either trailer, truck or skid mounted. This is view of trailer mounted unit.



Typical strip chart recording, copy of which is furnished to operator at conclusion of job for checking and record.

For normal casing jobs the hydraulic tong has shown its ability for fast operation. Spinning speed in high gear is approximately 125 rpm; make-up speed in low gear is about 15 rpm. On a recent job in the West Texas area, with the employment of the hydraulic tong, a 5150-ft string of 8⅝ in. casing was run in the hole in 2 hours and 10 minutes. On another job in the West Texas area a 13,600-ft string of 5½-in. was run in 7 hours and 10 minutes, including an hour and 10 minutes shut-down time chargeable to the well operator.

Torque Recorder

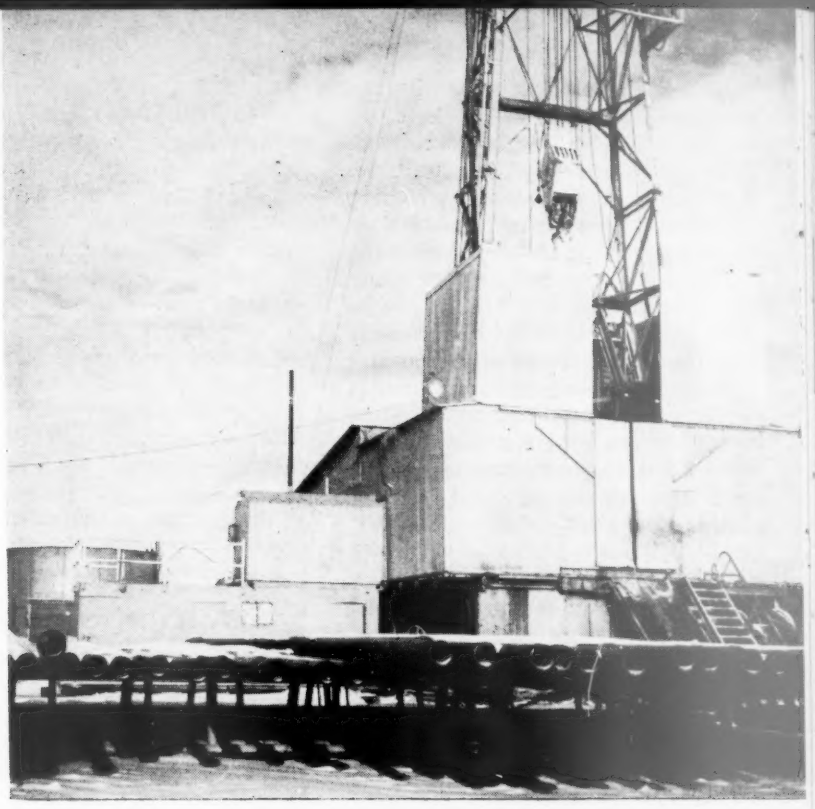
Another unique feature available with the hydraulic tong is a tong torque gage that is connected to a strip chart recorder calibrated up to 15,000 ft-lb torque, and actuated by a hydraulic load cell installed between the tong and back-up line. The gage is mounted on the tong directly in front of the tong operator. By the use of a second pointer, which is pre-set at the desired position on the face of the gage, the tong operator has a reference directly in front of him by which he can establish and maintain the desired and uniform torque make-up on each joint of casing. This recording also shows the elapsed time involved in the running of each joint as well as any shut-downs that may occur. At the conclusion of the job a copy of the chart is supplied to the operator and becomes a permanent record for his files of that particular job.

Hydraulic System

The tong is powered by a vane type hydraulic motor developing 23 hp at 2000 rpm and 2000 psi. Power is transmitted through a rugged alloy steel gear train to the drive ring. Speeds are controlled through manual operation of the control valve. When making up shouldered pipe, stall may be controlled by a quick adjustment of a pressure relief valve located in the circulating system. Die contact is applied from 3 points spaced at 120 deg phasing. Pressure is exerted evenly at each of these points minimizing the possibility of crushing pipe.

The main power unit is either trailer, truck, or skid-mounted, with a prime mover consisting of a 6-cylinder gas engine developing 38 SAE hp at 1200 rpm. The engine is coupled to a vane type hydraulic pump that is capable of delivering 24 gal per minute at 2000 psi. Seventy-five gallons of fluid is circulated in the system with temperatures not exceeding 140 F. Normal working pressures range between 1200 and 1600 psi. * * *

XUM



Derrick floor, substructure, drawworks, engine house, and pump house are completely enclosed during the severe winters

P 420.3

Nesson Anticline

Winter Drilling Operations

B. J. Sinex

THE Nesson Anticline is in the central part of the Williston Basin and located near the northwest corner of North Dakota. It is in the area that has probably the most severe winter weather in the United States. Its potentialities as an oil province have been long recognized, but only in the past four years, after recovery of commercial production, has a sustained development program been underway.

There are over 400 producing wells and this past winter there was an average of 15 active drilling rigs in operation. For the most part, these drilling rigs have been engaged in development operations. The severity of the weather is partially indicated by data recorded by the U.S. Weather Bureau, as shown in Fig. 1. This is only part of the story because the high winds occurring during the winter months very often accompany the lowest temperatures. Temperatures lower than 15 deg below zero are frequent and of longer duration than the occasional days when the temperature is above freezing.

Records show that there has been snowfall in every month except July and August. When the snow accumulations are accompanied by high winds, blizzard conditions frequently exist without snowfall. By way of contrast, climatic conditions existing in central Oklahoma indicate that temperatures are predominately above freezing with the coldest mean monthly temperature, being 37.6 F, occurring in January and the annual snowfall equivalent to one month's mean total in northwestern North Dakota. With severe winter climatic conditions in existence, it has been necessary that the operator under day-work contracts, limit day work costs to actual cash operating cost, plus $100 per 24 hour day, when a rig is shut down due to severe cold, storms, or inaccessible roads in excess of 24 consecutive hours. To underestimate the necessity of a carefully planned program for winter drilling operations is to incur added expenditures, lost time, and discomfort—if not suffering, of personnel. Weather conditions make it necessary to have drilling rigs fully winterized to protect against high winds, heavy snowfall and sub-zero temperatures by October 15, and usually by April 15 the major part of the winterizing may be discarded.

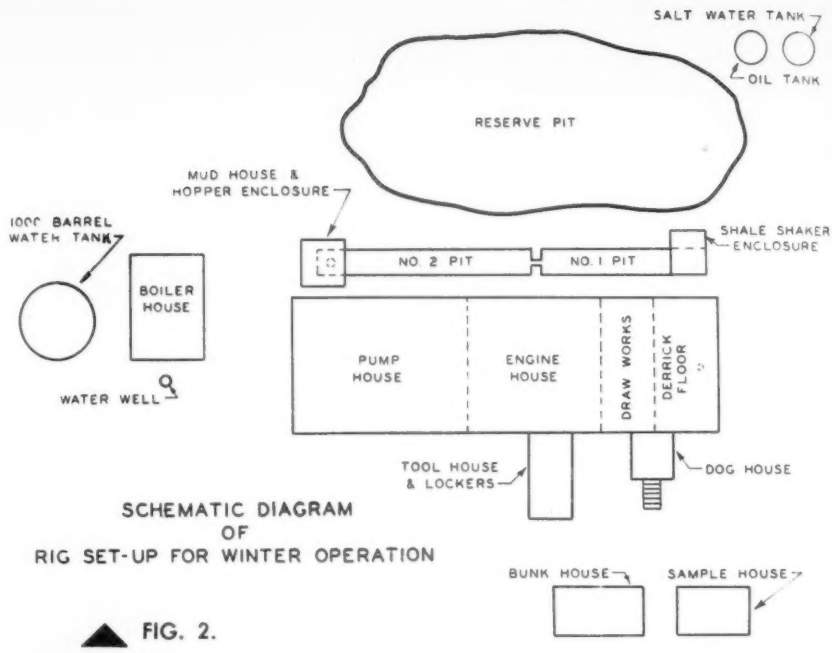
With the initial operation of staking a location for a drill site, it has been found that section corner markers may be covered with snow, creating a problem of locating, with trouble equal to or greater than surveying in traverse lines. After staking the location it is necessary to clear the drill site of snow. A more serious problem is the digging of reserve pit and cellar. Because of the frost line, which extends to as much as 5 or 6 ft in depth, it is often necessary to heat the ground by burning many tons of coal and removing several feet of soil. Usually with the second heating the pit can be excavated to the desirable depth. In conjunction with the use of heat, air drills are used to loosen the frozen soil when digging the cellar. Cost of clearing a winter location on average surface conditions is tripled, over moderate weather preparations. This problem was more acute during the first winter of full scale operations on the Nesson Anticline, being alleviated the following winter by advance preparation of locations for the sub-zero weather.

The depth at which current development is carried to, on the Nesson Anticline, ranges between 8200 and 8600 ft. Some rigs operating in the area are approaching their depth limits while others could drill below 12,000 ft. Horse-power ratings of rigs will vary from 750 hp to 1200 hp. Drawworks and engines are mounted on either a 9-ft, 10-ft or 12-ft substructure which also supports a jackknife derrick. Usually the mast is 133 ft or 142 ft in

EXCLUSIVE

height. Each rig is equipped with two pumps, normally a 250 hp, 7¼ by 15 in. and a 500 hp, 7¾ by 18 in. with liner size governed by pump pressures desired. Most operators have been using pump pressures of from 1000 psi to 1600 psi. Jet type bits and high pump pressures have contributed to faster rates of penetration in this area. Blow-out preventers in use are hydraulically controlled with pipe rams and positive shut-off valve, in which diesel oil is used as the hydraulic medium. Dual light plant systems are standard equipment to insure power for illumination on drilling rigs during added hours of darkness on winter nights.

Generally all contractors adhere to much the same rig layout pattern. A schematic view of this pattern can be seen in Fig. 2. Many problems, such as supplying heat where needed throughout the rig, protecting against heavy snow, along with the highly competitive operation between contractors to reduce overall time from skid to spud, have developed rigs into portable compact units. Where development on the Nesson Anticline has been continuous, there has been a decided economic advantage by skidding from one location to the next. To faciliate this movement, provisions have been made to remove a small panel over skid windows at the four corners of the substructure supporting the derrick, drawworks and engines. Skid beams are then inserted and, in turn, placed on dollies. With removal of a panel on the "V" door side, the rig is ready to be skidded back off the Christmas tree. Usually two or three heavy tractors furnish adequate skid power. Winter skidding with 5 or 6 ft of frost in the ground usually causes less damage to the surface than under moderate temperatures.



SCHEMATIC DIAGRAM
OF
RIG SET-UP FOR WINTER OPERATION

▲ FIG. 2.

Each winter drill site requires a water well, usually located 115 to 125 ft from the well bore, back of the pump house. Failure to obtain a water well means, in addition to water well cost, normally drilled at $4 per ft, expense of supplying water by trucking. Large volumes of fresh water are consumed to the mud stream in fast drilling in the upper part of the hole, with initial usage of 100 bbl per hour tapering down to 35 bbl per day for the lower section of the hole. Water hauling is done by tank trucks which operate under controlled hourly rates which vary with carrying capacity. From an analysis of numerous trucking invoices, it was found that average hauling costs were nearly 18 cents per bbl. Fresh water is stored in a 1000-bbl bolted steel tank equipped with steam coils. The pipe line carrying water from storage to the rig is laid along side the steam line from the boiler, both being covered with cotton seed hulls and boxed in.

Another burden on water supply in addition to water used for drilling fluid, washing down floors, hydramatic brakes, engine cooling, etc., is that used in steam boilers. The main source of heat is supplied by a steam boiler, the horsepower of which ranges from 45 hp to 90 hp. A skid-mounted boiler is located immediately behind the pump house and is suitably enclosed with corrugated steel or sheet metal siding.

Steam heat is transmitted throughout the rig where needed for machinery and comfort of rig personnel. When it becomes necessary to have steam heat available, an additional man per tour must be employed to fire the boiler. Ordinarily these boilers carry from 50 to 60 psi steam pressure and consume from 200 to 250 bbl of water per 24 hour day. Based on the hauling cost of 18 cents per bbl, expense of supplying boiler feed water will range from $36 to $45 per day.

Most boilers are fired on natural gas, burning around 50,000 cu ft per day to maintain the necessary supply of steam. Gas based on the price of 35 cents per thousand cu ft would cost

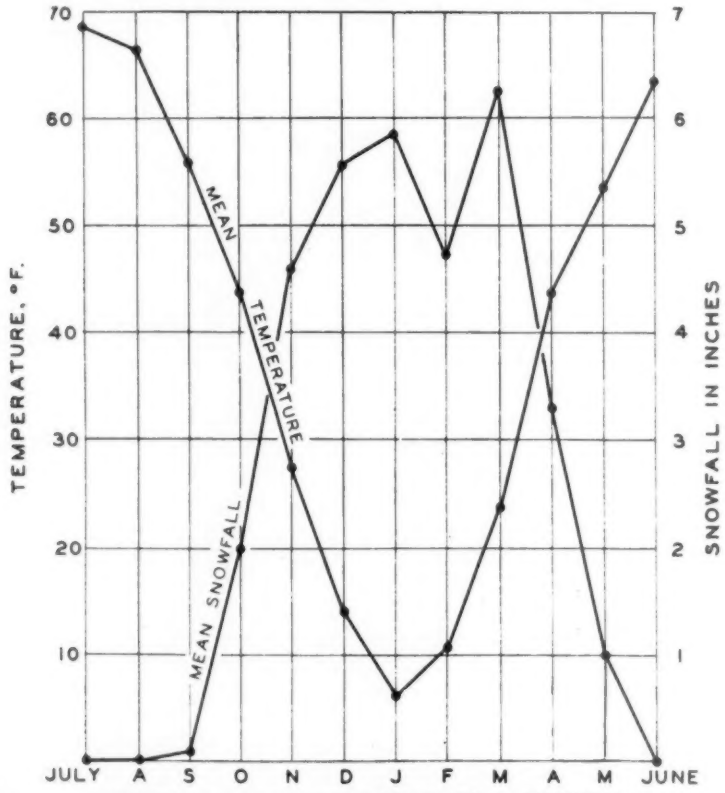


FIG. 1. ▶ MONTHLY MEAN TEMPERATURE & SNOWFALL
WILLISTON, NORTH DAKOTA

$17.50 per day. In the event that natural gas is not available and other fuel is used, such as coal or oil, costs will be increased substantially. Considering wages for three additional men at $13.60 each, plus cost of supplying water if water well is not available, plus cost of fuel, it can be seen that the necessity of using a boiler will add approximately $100 per day to drilling costs.

For handling of drilling mud, two all-steel, portable skid-mounted mud tanks are used, set on 3 by 12-in. by 12-ft runners. Often the board runners are destroyed or cannot be removed after drilling operations are complete because excess water and mud freeze around the tank bases. As a safety measure, mud tanks are never enclosed since an oil emulsion drilling mud is used. Even though fresh water is used to drill the upper part of the hole, no special facilities are needed to heat mud tanks as long as circulation is maintained. In the event of a breakdown then it would be necessary to discharge fresh water mud from mud tanks. A breakdown occurring after conversion to salt-saturated oil emulsion mud does not require removal of mud. For ease of treating the mud stream, a mud house with hopper inside sets level with the top of the portable mud tanks and at the end of the tank where the mud pump suction is located.

Matting boards, ordinarily 3 by 12-in. by 30 ft, are spaced 6 in. apart completely underlying the substructure which supports the derrick, drawworks, and the engine house. Additional matting is laid back of the substructure to accommodate the mud pumps. Some rigs employ runner type matting composed of three sections running the entire length of the substructure. In both cases after rough leveling of locations, 4 to 5 inches of pit-run gravel is laid down, lending to final ease of leveling. Experience has demonstrated that a porous media must underlie matting boards to insure their removal upon well completion. Prior to this practice, considerable time and expense were expended to remove ice-embedded matting for re-use. Another practice to prevent ice embedment is the spreading of approximately ½-in. of aquagel under matting boards. Absence of agitation when waste water contacts aquagel creates an impervious blanket allowing water to run off. Strands of steel cable have also been used under matting boards to allow their removal more easily.

Early efforts to enclose drilling rigs were of a crude design, expensive and very impractical. Siding consisted of 2 by 4-in. frame sections covered with corrugated tin which was removed, in part, when skidding from one location to the next. To eliminate this cumbersome and expensive means of winterizing drilling rigs, the operator paid the contractor a lump sum to design and erect permanent type siding. Contractors have since enclosed their rigs with sections of corrugated iron bolted on angle iron frames, which are considerably more durable and need not be removed during skidding operations. Most of the siding used for enclosing drilling rigs has been designed and supplied by steel fabricating concerns with costs ranging from $8000 to $15,000 per rig. This cost may be spread over several wells under an extended drilling program. If only one well is to be drilled and it becomes necessary for the operator to furnish winter siding, a substantial charge against a well is incurred.

The Author

Bradford J. Sinex has learned about drilling in the severe North Dakota winters while serving as assistant district superintendent with Amerada Petroleum Corporation's production department at Williston. He joined Amerada in 1940 as a petroleum engineer and assumed his present position in 1954.

He was graduated from the University of Oklahoma in 1938 with a BS in petroleum engineering and was employed by Lion Oil and Refining Company until 1940.

Derrick floor, substructure, drawworks, engine house, and pump house are completely enclosed. Rig design controls the method by which these various units are to be housed. All rigs employ the cantilever type of derrick with housing reaching to the top of the "A" frame. Extension of the housing to this point reduces the severity of down draft on the rig floor. Entrance of the "V" door leading to the ramp serving the pipe racks is protected by retractable canvas covers, or more often a servicable set of steel doors that either swing out or are suspended on a track by rollers. It is only necessary to have this entrance open when picking up drill pipe, running casing or bringing heavy materials onto the derrick floor. All dog houses sit level and open directly onto the derrick floor. Combination steam and blower type heaters, in addition to gas-fired heaters, are used to heat the derrick floor and pump house and only steam heat is used beneath the derrick floor around the blowout preventors. During the running of drillstem tests, only the blower-steam type heaters are used. The danger of gas accumulation, which will not disburse readily due to the surrounding enclosure, prohibits the use of gas-fired heaters. Exhausts from steam heaters are joined and utilized by discharging into cellers, fresh water storage, rat hole and fresh water mud.

To protect the derrick man from severe cold and high winds, the racking platform is surrounded by corrugated iron on an angle iron frame. A steam line running up to the racking platform furnishes heat for the derrick man. Steam exhaust from the heater may be turned into the stand pipe as an added precaution to prevent its freezing while pulling and running drill pipe. Usually, after breaking off the kelly and prior to pulling the drill pipe out of the hole, steam is turned in at the base of the stand pipe until all of the mud from stand pipe, rotary house, and kelly joint is removed.

Two-way radio equipment mounted in field cars and on drilling rigs has contributed toward personnel safety as well as the orderly movement of materials and the dispatching of orders. Should weather conditions prevent leaving the drilling rig, a well insulated dog house supplied with food and equipped with sleeping quarters for as many as six persons is available.

In running electric logs, radioactive logs, or perforating, special protection is not required for the equipment with the exception of certain type of gamma-ray counters that must be protected from temperatures of — 15 deg or below. Ice formation on sheaves used to lower logging cables must be closely watched so that the cable does not jump the sheave. Cementing trucks are not enclosed and precaution must be taken against the freezing of fresh water when circulating through pumps. Pump heads on cementing trucks are preheated with open fire by pouring kerosine on cloth sacks laid on top of pumps or by various types of flame throwers. During the running of the oil string, it has proved good practice to have two cement trucks on each job with extra operating crews. This practice reduces mixing time of cement and allows the plug to be pumped down in one-half the time required by a single cement truck. It also gives an added safety factor in event that one cement truck develops trouble.

As drilling operations continue on the Nesson Anticline through the winter months, it becomes more evident that a well organized drilling program is necessary to insure the most economic development of this vast area. * * *

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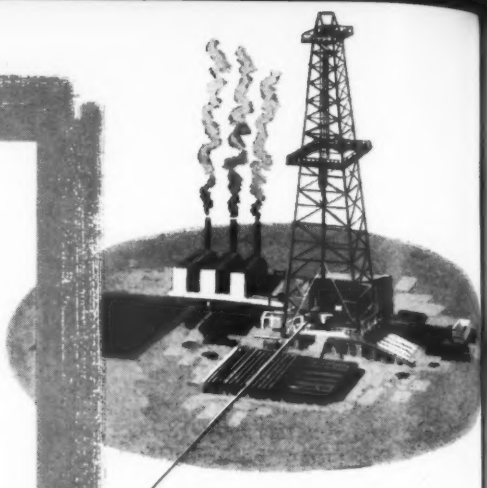

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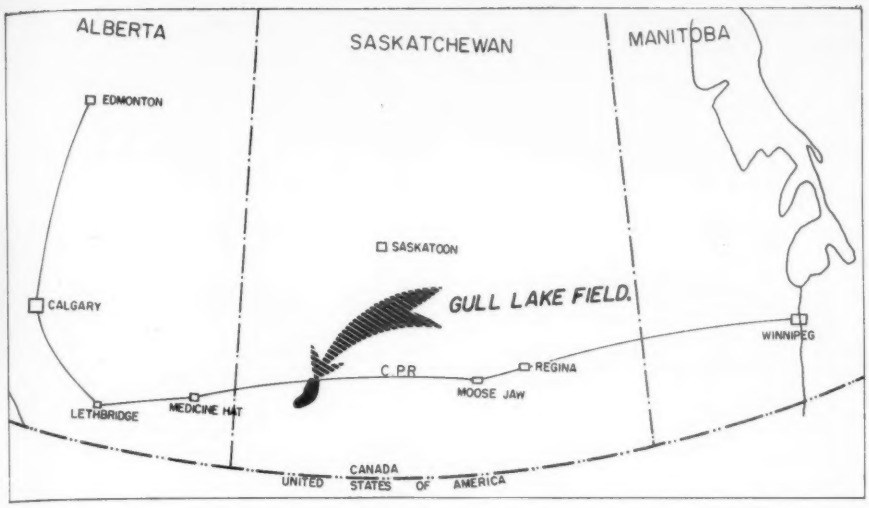
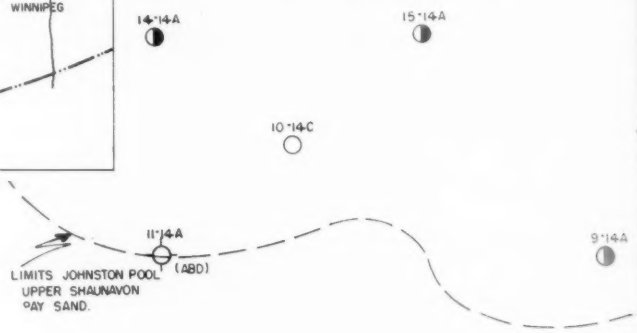


FIG. 1. Conversion of Well 10-14C from Basal Cantuar sand at 3568 ft to Upper Shaunavon at 3850 ft means 20 acre spacing.



Virtual non-producer close to an abandonment was transformed into an oil well with reasonable payout

Saskatchewan

Hydrafrac Success

Jack Menneer*

WELL completions in the Province of Saskatchewan can present the operator with a problem. Many possible productive pays are tight and/or thin. A stimulus is necessary to make them yield oil. The following case history points out the special problem and illustrates the success that was obtained.

Anglo American Exploration, Ltd., produce the multi-zoned Gull Lake field in southwest Saskatchewan. The problem well was 10-14C.

Well 10-14C was drilled with the

*Head, Petroleum Engineering Department, Anglo American Exploration Ltd., Calgary, Alberta, Canada.

PERIOD	Formation	MEMBERS	APPROX. DEPTH	COLUMNAR SECTION	LITHOLOGY
LOWER CRETACEOUS	Blairmore	UPPER BLAIRMORE	± 3400		SHALE: light to dark grey inter bd. fine grained sandstone Continental
		Cantuar Mkr	± 3500		SHALE: black
		Cantuar Sand	± 3500		SILTSTONE: green, fine grained generall tight
			± 3560		SHALE: grey grn. silty Continental
		BASAL CANTUAR SAND	± 3620		SAND: white, fine grained silty
JURASSIC		UPPER VANGUARD (J-1-A)	± 3640		Unconformity (?) SHALE: red, green calc.
		MIDDLE VANGUARD (J-1-B)	± 3670		SAND: white & grained silty to shaly calc. oil st.
		LOWER VANGUARD (J-1-C)	± 3840		SHALE: green waxy calc.
		UPPER SHAUNAVON (J-2-A)	± 3890		Sandstone & limestone
		LOWER SHAUNAVON (J-2-B)	± 3890		ls. buff. oolitic

LEGEND
Gas
Oil
Shale
Sandstone
Limestone

FIG. 1A. General stratigraphic section, Gull Lake, Saskatchewan.

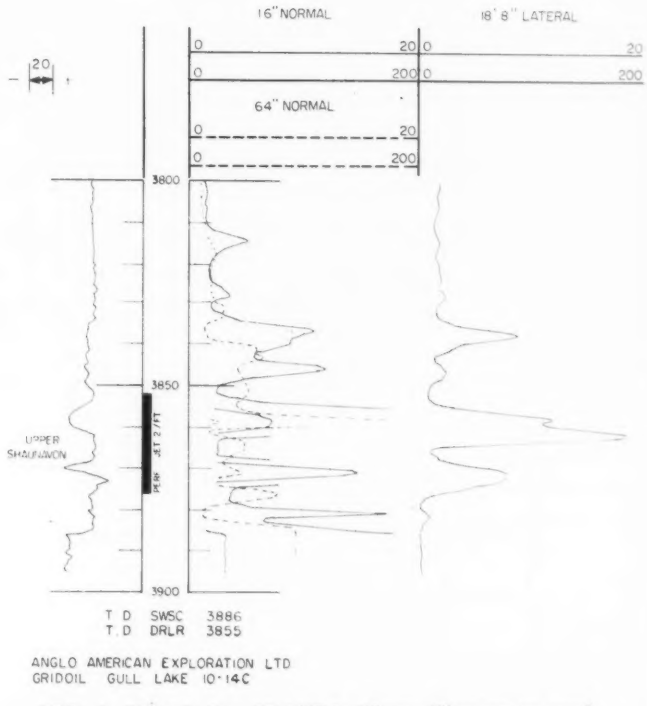


FIG. 2. Electric log 10-14C in Upper Shaunavon sand.

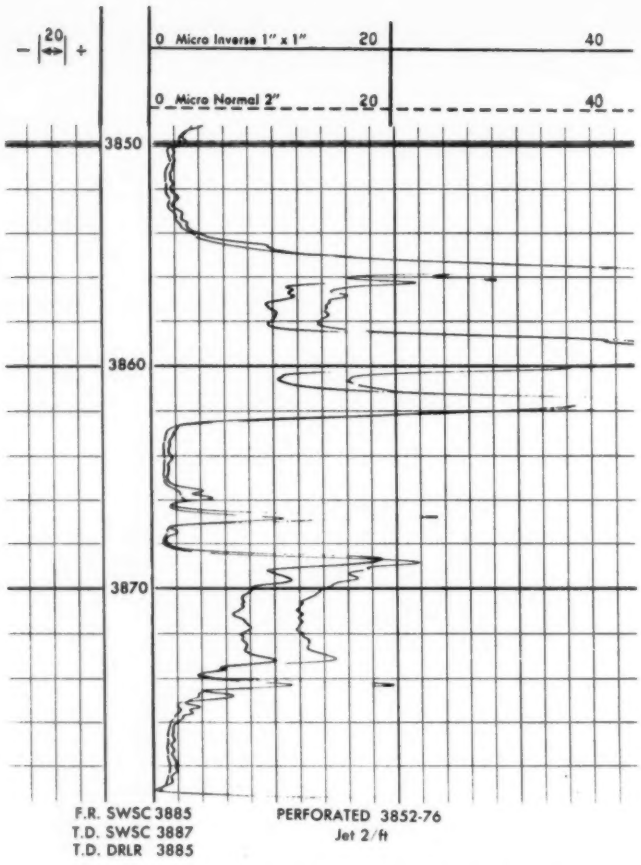


FIG. 3. Micro log in Upper Shaunavon 10-14C.

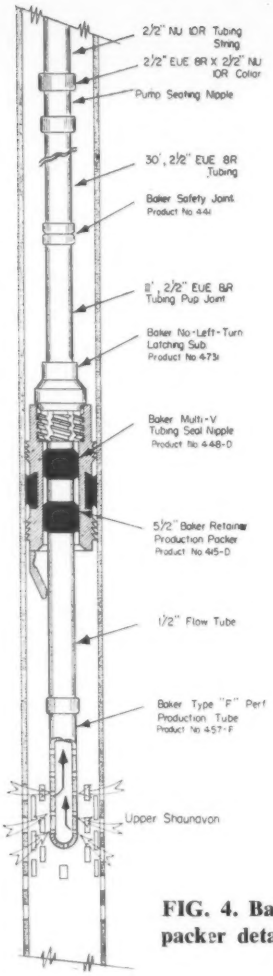

2½" NU 10R Tubing Shrng
2½" EUE 8R x 2½" NU 10R Collar
Pump Seating Nipple
30', 2½" EUE 8R Tubing
Baker Safety Joint Product No 444
11', 2½" EUE 8R Tubing Pup Joint
Baker No-Left-Turn Latching Sub Product No 473i
Baker Multi-V Tubing Seal Nipple Product No 448-D
5½" Baker Retainer Production Packer Product No 415-D
1½" Flow Tube
Baker Type "F" Perf Production Tube Product No 457-F
Upper Shaunavon

FIG. 4. Baker packer details.

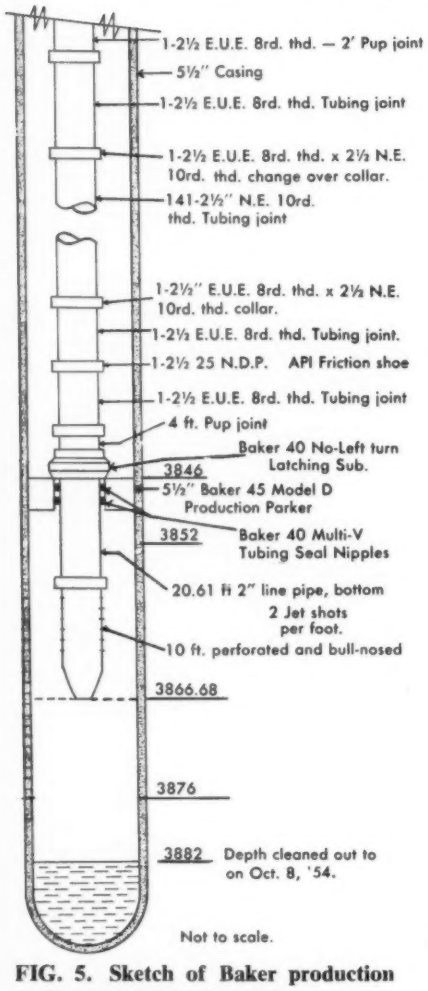

1-2½ E.U.E. 8rd. thd. — 2' Pup joint
5½" Casing
1-2½ E.U.E. 8rd. thd. Tubing joint
1-2½ E.U.E. 8rd. thd. x 2½ N.E. 10rd. thd. change over collar.
141-2½" N.E. 10rd. thd. Tubing joint
1-2½" E.U.E. 8rd. thd. x 2½ N.E. 10rd. thd. collar.
1-2½ E.U.E. 8rd. thd. Tubing joint.
1-2½ 25 N.D.P. API Friction shoe
1-2½ E.U.E. 8rd. thd. Tubing joint
4 ft. Pup joint
Baker 40 No-Left turn Latching Sub.
3846
5½" Baker 45 Model D Production Parker
3852
Baker 40 Multi-V Tubing Seal Nipples
20.61 ft 2" line pipe, bottom
2 Jet shots per foot.
10 ft. perforated and bull-nosed
3866.68
3876
3882
Depth cleaned out to on Oct. 8, '54.
Not to scale.

FIG. 5. Sketch of Baker production packer and production string.

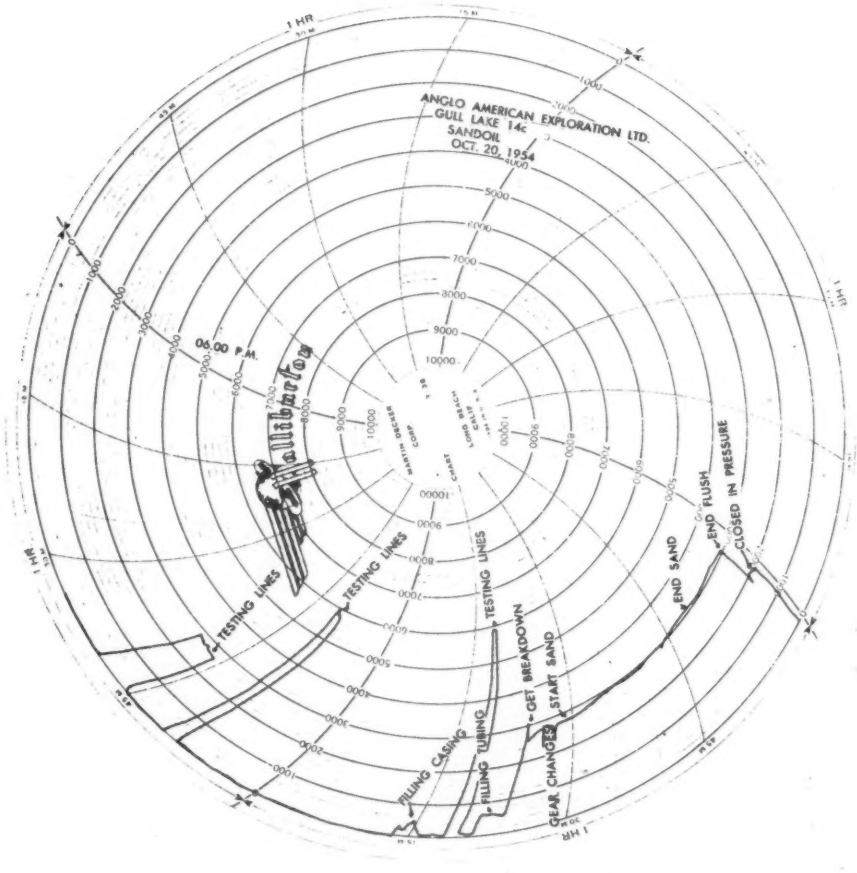


FIG. 6. Hydrafrac graph well 10-14C.

Table 1. Well treatment report.
ANGLO AMERICAN EXPLORATION LTD.
First 500 gal mud acid wash.
Conversion Basal Cantuar to Upper Shaunavon.

Well: Gridoil Gull Lake 10-14C — Field: Gull Lake
Location: 10-14-13-19-W3 — Treat No.: 1 — Date: Oct. 10, 19 54

WELL DATA

Formation: Upper Shaunavon
Pay-from: 3852 ft — To: 3876 ft.
Present total depth: 3882 ft — P.B. from: 3888 ft

Pipe data—
Casing size: 5½ in. — Wt.: 15.5 lb
Casing depth: 3888 ft. — Sks. cement: 120
Liner size: — Wt.:
Liner depth-from: — To:
Liner description:
Tubing size: 2½ in. — Depth: 3867 ft.
Packer-type: Baker Mod. D — Depth: 3846 ft.
Packer furnished by:

Completion data—
Date: — Cable tool:
Rotary: √ — Drilling fluid: Mud
Size open hole:

Perforating data or pay zones

Shots/ft	From	To
2	3852 ft	3876 ft

Production—

	Oil	Water	GOR
Initial			
Present			

Acidizing, shooting and logging record—

DETAILED RECORD OF TREATMENT

Time A.M. or P.M.	Pressure, psi: Casing	Pressure, psi: Tubing	Remarks	Bbl of acid: Out of tanks	Bbl of acid: In formation	Bbl of acid: Per reading	Bbl of acid: Per minute
7 am			Arrival at location with 500 gal of Mud acid				
			Hooked up lines while swabbing well				
			Fill 10 bbl				
			Bleed 12 bbl				
9:55	900		Pumped 7 bbl to fill casing				
			Flush 3 bbl				
10:11		0	Spot 10 bbl oil in tubing				
10:19 am			Start acid				
10:23			Acid in tubing. Fill trailer with oil.				
10:31			Start oil behind acid.	12	0	0	0
10:32	2800			14	0	0	0
10:33	3500			14	0	0	0
10:35	4000		Bled off tubing. Unseated tubing seal nipples to bleed acid to top of packer.				
11:30	0		Start displace 8.5 bbl oil.				
11:35			Reseat tbg seal nipples in packer.	22.5	0	0	
11:45			Acid at perf. Start squeeze.	23.5	0	0	0
11:48	2500				1		1
11:50	3000			24.5	2		
11:54	2700			28.5	4		2
11:58	2400			37.5	13		4
			Left location				

If treatment is not conventional limestone formation treatment to increase oil or gas production, state purpose of treatment.

J. Parker
Service Engineer
E. G. Fisher
Company Representative

Table 2. Well treatment report.
ANGLO AMERICAN EXPLORATION LTD.
Second mud acid wash, 1000 gal
Conversion Basal Cantuar to Upper Shaunavon.

Well: Gridoil Gull Lake 10-14C — Field: Gull Lake
Location: 10-14-13-19-W3 — Treat No.: 2 — Date: Oct. 11, 19 54

WELL DATA

Formation: Upper Shaunavon
Pay-from: 3852 ft — To: 3876 ft.
Present total depth: 3882 ft — P.B. from: 3888 ft

Pipe data—
Casing size: 5½ in. — Wt.: 15.5 lb
Casing depth: 3888 ft. — Sks. cement: 120
Liner size: — Wt.:
Liner depth-from: — To:
Liner description:
Tubing size: 2½ in. — Depth: 3846 ft.
Packer-type: — Depth:
Packer furnished by:

Completion data—
Date: — Cable tool:
Rotary: — Drilling fluid:
Size open hole:

Perforating data or pay zones

Shots/ft	From	To
2	3852 ft	3876 ft

Production—

	Oil	Water	GOR
Initial			
Present			

Acidizing, shooting and logging record—
500 gal. mud acid.

DETAILED RECORD OF TREATMENT

Time A.M. or P.M.	Pressure, psi: Casing	Pressure, psi: Tubing	Remarks	Bbl of acid: Out of tanks	Bbl of acid: In formation	Bbl of acid: Per reading	Bbl of acid: Per minute
11:30 am			Arrival at location with 1000 gal of Mud acid				
			Fill 22 bbl				
			Tubing swabbed dry				
			Bleed 2 bbl				
			Flush 2 bbl				
11:50 am			Start acid.				
11:54				22	0		
11:56	1000		Take on oil.	26	4	4	2
12:02	1600		Start pumping.				
12:03	1600			28	6	2	2
12:05	1600			30	8	2	1
12:06	1600			32	10	2	2
12:09	1700			38	16	6	2
12:11	1800			44	22	6	3
12:13	1800			46	24	2	1
12:15	2000		2 bbl flush oil.	48	26		
			Left location				

If treatment is not conventional limestone formation treatment to increase oil or gas production, state purpose of treatment.

J. Parker
Service Engineer
E. G. Fisher
Company Representative

primary objective as Basal Cantuar oil production at 3568 ft. Casing, 5½ inches, was set at 3885 ft with a secondary objective, for production at a later date, the Upper Shaunavon sand at 3850 ft (approx). (See Figs. 2 and 3.)

The Basal Cantuar oil pay went to high GOR after a year and remedial work was necessary. Due to many factors, such as workover cost, future water flood possibilities for the reservoir, etc., it was operationally expeditious to recomplete the well in the Johnston Pool pay, namely, the Upper Shaunavon at 3850 ft. This was to be achieved by packing-off the Basal Cantuar that was open through perforations at 3588 to 3592 ft and to perforate the Upper Shaunavon. Original intention was to use a production packer, but the Regulatory Government body called for a more assured pack-off. In consequence a Baker Model D production packer (drillable) was installed. (See Figs. 4 and 5.)

Well 10-14C (Upper Shaunavon) was bounded to the north and east by producing wells and a diagonal half offset to the southwest was an abandonment.

Reservoir Characteristics

Well 10-14C Upper Shaunavon has 20 per cent porosity, 50-150 mds (est). Permeability, 10 feet pay thickness, .97 shrinkage, 0 API gravity. Recovery was calculated to be 53,000 bbl stock tank oil.

Geologically, the Johnston Pool Upper Shaunavon is described as a thin, lenticular, calcareous sand that is stratigraphically situated to form a trap.

Conversion Procedure

Well was an insert pumping, Basal Cantuar producer at 3568 ft. Killed well at 7000 psi, and pulled pump loose. Pulled rods, dismantled tubing head and put on blowout preventer. Ran in with tubing and encountered a bridge at 3641 ft and was unable to circulate past 3782 ft. High winds retarded progress and it was necessary to re-run tubing with a 4¾-in. bit and a Baker Model C Roto-Vert casing scraper. Cleaned out and circulated at 3882 ft.

Selective perforating in the Upper

Table 3. Hydrafrac report.
HALLIBURTON OIL WELL CEMENTING CO. LTD.
Edmonton, Alberta, Canada

SERVICE REPORT

Ticked No. 2138 2-F

Treatment: Sand-oil — Date: October 20, 19..54
Company: Anglo American Oil Co. — Address: 326 9th Ave., W. Calgary, Alberta
Field: Gull Lake — Well: 10-14C — Location: 13-19
Formation: Upper Shaunavon — Interval: 3852-76 ft — Total depth: 3882 ft.
Casing: Size: 5½ in. — Weight: 15½ lb — Set at: 3885 ft — Perf.: 2 jets/ft.
Liner: Size: None — Weight: — Set at: — Perf.:
Open hole from: — To: — Size: — Perf.:
Tubing: Size: 2½ in. — Weight: 6½ lb — Set at: Tool 20 ft 2 in. line pipe.
Tool: Type Baker Mod. D prod. packer. — Size: 5½ in. — Set at: — Tail pipe: (see over)
Displacement: Tubing: 2 bbl. — Casing or open hole: — Annulus:
Type fluid: In hole: Oil — For displacement: Oil
Production previous to treatment: Oil: 10 BPD — Water: nil — Gas: GOR 25
Procedure: Fill tubing and casing. Get b'down pressure and feeding rate. Mix 10,000 lb No. 22 Hydrafrac sand starting at 1 lb per gal. and increasing to 4 lb per gal. if possible. Displace and flush with 43 bbl of oil.
Operator: H. W. Acteson — Witness: E. G. Fisher

Time	Pressures Tubing	Pressures Casing	Gallons in formation	Bbl per min. oil only	Remarks
6:50	Test lines to 6000 psi— Lines OK				
7:10	Filling casing		7.14		Casing full
7:18	Test lines to 6000 psi				
7:21	Filling tubing				
7:25	3000–2600			3.8	Get b'down pressure and feeding rate.
7:29	2800			3.8–4.0	St. mixing sand at 1.0 lb/gal.
7:32	2800			4.0	Increase sand to 1.4 lb/gal.
7:36	3000			4.0	Increase sand to 2.4 lb/gal.
7:41	3000			4.0	Increase sand to 3.4 lb/gal.
7:45	3000			4.0	Increase sand to 3.8 lb/gal.
7:49	3100			4.0–5.4	End of sand—Start displacement.
7:57	3100			5.4	End of flush.
7:59	2000				Closed in pressure.

SUMMARY

Oil used: Johnston pool crude
B'down — 19 bbl — 5 min.
4158 gal mix — 99 — 20
Flush — 43 — 8
Injection rates: B'down — 3.8 bbl/min.
Mix—oil — 5.0
oil & sand — 5.5
Flush — 5.4
Ave. mix and flush — 5.5
Sand: 100 sacks No. 22 Hydrafrac sand (11 bbl)
Unit used: 314 and 279 (T-10 A.C.'s)
Weights: Maximum 3.8 lb/gal.
Maximum 10 lb/gal.
Average 2.4 lb/gal.

Note: Tail pipe. 20 ft 2 in. line pipe. Bull-nosed. Bottom 10 ft perf. with ⅜ in. diameter holes. Casing had a perforated section (about 200 ft above tool) which took fluid at 400—500 psi, so no pressure was held on annulus during job.

Table 4. Laboratory report.
HALLIBURTON OIL WELL CEMENTING CO. LTD.
Edmonton, Alberta, Canada

To: Anglo American Exploration Limited, Calgary, Alberta. — No.: Project 109-54 — Date: October 23, 19..54

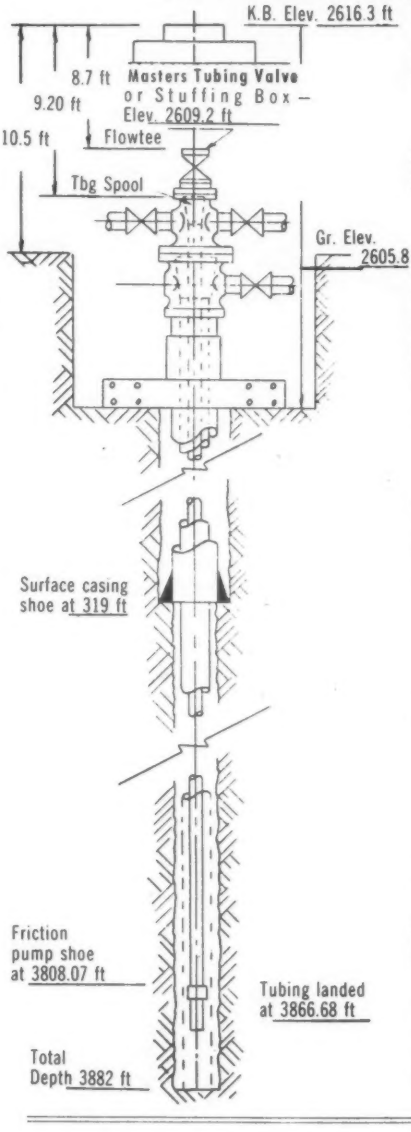
We give below results of our examination of: Johnston crude as used for sand-oil fracturing at Gull Lake. Viscosities were determined with a Brookfield viscometer at the indicated temperatures.

Temperature	Viscosity	API Gravity
60 F	80.5 cps	23.1 deg at 60 F
120 F	25.0 cps	

Sand settling rate = 0.97 ft/min.

Respectfully submitted,
A. S. Mitchell
Engineering Department

Table 5. Production equipment report.



Conversion Basal Cautuar to Upper Shaunavon.

Date: October 9, 1954
Well: Gridoil Gull Lake 10-14C

WELL HEAD

Manufacturer: Rector
Description: Series: Redhead
Size: 10¾x5½x2½

TUBING

2 in. perf. nipple	22.74
Latching sub and pup	4.68
Pump Shoe	1.00
141 jts., 2½ in. 6.4 # 10rd Thd., Rge. 11	3738.90
Plain End Tubing: 3 jts. 2½ EUE 8rd thd.	90.86
2x2½ EUE 8rd thd. Pup jt.	2.00
Total length of string	3857.98 ft
Dist. Flowtee to K.B.	8.70 ft
Tubing landed at	3866.68 ft
Length of string below top of pump shoe	58.61 ft
Distance stuffing box below K.B.	7.10 ft
	65.71 ft
Distance pump shoe below stuffing box	3800.97 ft

Note: All measurements are "threads off". In each case cross out the terms which do not apply. If well is on pump fill in details of pumping equipment, as shown below.

PUMPING EQUIPMENT

2½x2x1 ¼x12 RWT — 12.00
Description: Oilmaster Multiple Tube — Friction holddown
Sucker rods: 101-⅝, 50-¾ — 3790
Pony rods: 1-4x⅝, 1-4¾ — 8
Polish rod: 1¼x11 — 8
Total length: 3808 ft
Pump jack: National E11SN 57 DP
Power unit: Model B Witte #5768
Engineer: R. L. Loveseque

Shaunavon was desired, but as correlation with the casing collars was not too good the complete interval 3852 to 3876 ft was perforated with 2 jet shots per foot.

Next, the Baker Model D drillable production packer was set at 3846 ft and seal nipples and tubing string were run as follows: (See Fig. 5.)

20 ft 2⅞ in. line pipe, bottom 10 ft perforated and bull nosed	20.61	
2 No. 40 tubing seal nipples	2.13	
Total tail pipe	22.74	ft
1 No. 40 No-left turn latching sub and 4 ft pup, 2⅞-in. EUE 8R	4.68	ft
1 single 2⅞-in. EUE 8R tubing	30.19	ft
1 25 NOP API friction pump shoe	1.00	
1 single 2⅞ in. EUE 8R tubing with 8Rx10R change-over collar on top	29.80	
8Rx10R change-over collar on top	29.80	
141 jts 2⅞-in. non upset 10R tubing	3736.90	
1 jt 2⅞-in. EUE 8R tubing	30.67	
1 pup jt 2⅞-in. EUE 8R tubing	2.00	
Total tubing string	3835.24	ft
Tubing string	3835.24	
KB to flow tee	8.70	
Tubing into packer	3843.94	ft
Tail pipe	22.74	
Bottom of tubing	3866.68	ft

Pulled 45,000 lb on latching sub to check seat and headed up well to wash with mud acid.

Tubing was swabbed dry with a 22 bbl oil recovery. Hooked-up and filled casing with 7 bbl oil. Basal Cantuar perforations took oil at 500 psi. Ten bbl oil was spotted in tubing and was followed by 12 bbl mud acid (500 gal). (See Table 1.)

The Upper Shaunavon perforations at 3852-3876 ft would not take oil at 4000 psi. (Packer and seals held.) Seal nipples were pulled loose and acid was displaced to top of packer. Seals were re-set and acid was fed away at 3000 psi and 1 bbl per minute. At end of squeeze, acid was going away at 2400 psi and 4 bbl per minute. Overflushed with 3 bbl oil and swabbed for 7 hours.

Swabbing results were 28 bbl oil in 3 hours and then pulled oil-dry swabs for 4 hours with about 1 per cent water cut. Well was shut-in overnight and fluid was found at 2000 ft in the morning. Swabbing operations were resumed

at an initial rate of 1 bbl oil per hour and .8 per cent water cut. Later, swabs had nil recovery.

A second mud acid wash was performed, 1000 gallon job (See Table 2). Initial feeding rate was 2 bbl acid per minute at 1600 psi and finally 1 bbl per minute at 1800 psi.

Swabbed tubing capacity and shut well in overnight. Fluid level next day was at 2600 ft and swab recovery was 9 bbl, thereafter dry swabs only. Some acid water was recovered.

The result of second acid wash was an equivalent daily production of 10-12 bbl oil per day. In order to evaluate, the well was placed on pump for production test.

Production test results with 1¼-in. by 42 inch stroke pump at 10 strokes per minute gave initially 14 bbl per day, BS&W 1.6 per cent and, eventually, 9 bbl per day of clean oil with .1 per cent sand.

As 1500 gallons and acid wash had failed to make a successful producer, plans were made to Hydrafrac.

Hydrafrac

Principle involved was to frac with a large volume of Ottawa sand at high injection rate. It is to be remembered that the frac operation had to be conducted through the Baker packer. (See Table 3 and Fig. 6.)

Quantity of Ottawa sand employed was 10,000 lb and 4158 gallons Johnston Pool (Gull Lake) crude. (See Table 4.) Initial feed was 3000 psi, 4 bbl oil per minute and 1 lb sand per gallon, finally 3000 psi, 4 bbl oil per minute, and 3.8 lb sand per gallon. Shut-in well for 24 hours.

Well (See Table 5.) has produced consistently from the Upper Shaunavon since the Hydrafrac at 30 bbl oil per day, water cut 1.2 per cent, casing pressure 0, tubing pressure 5, 1¼-in. pump, 42-in. stroke, 7 strokes per minute. Or, in other words, a 200 per cent production increase has materialized.

Economics

Payout of conversion will be 6 months. An almost nonproducer has by a frac job become a successful oil well. * * *

Offshore Enlarges Operation

The Offshore Company of Baton Rouge, Louisiana, has purchased the contract drilling division of Southern Production Company of Fort Worth, Texas. Sale, involving over $8,000,000, gave Offshore 14 drilling rigs. Nine of the rigs are barge-mounted. The Offshore Company holds exclusive rights on several advance design patents by DeLong for pnematic jacking mechanisms used in the operation of portable deep-water drilling barges on the Gulf Coast.

Your lease can be a

producers pride

through properly scheduled maintenance

F. W. Robson

THOSE pumping leases powered with manually operated internal combustion engines require certain obvious routine daily operations. Certainly the units must be started and stopped, tanks must be gaged, oil runs witnessed, and lease and equipment inspected. There are, however, in most instances, free hours in every day which can be devoted to improvements in lease operations which will lower operating costs, thus extending the economic life of the property and insuring a greater oil recovery from the reservoir.

These improvements can best and most economically be gained by a definite plan of daily operation. Once this schedule is placed into effect, operations will grow better at a gradual rate and desirable lifting cost reduction will automatically appear.

Here is one plan. Use each day for the same kind of work at different units, or check all of the features of work and inspection at one unit, then move on to the next one. Construct a chart for recording your accomplishments during a week or month's time. Place the lease name and well number in the left-hand column, then merely mark down the date in the proper column of work done. A suggested chart is presented as Fig. 1.

A Clean Lease Is a Safe Lease

First, let's consider the premises. A symmetrical boundary around the immediate area should have good drainage, be free from grass or vegetation, extraneous inflammable material, and stumbling hazards. Earth impregnated with oil or salt water from the well will prevent the growth of grass and weeds. Also there are some reliable grass and weed killers on the market. Be sure the premises are neat and the ground firm.

Proper Alignment Saves Bearings

Second, let's examine the alignment features of the unit. Be sure the center line of the walking beam is exactly centered over the center line of the reducer case or center line between the main skids. A straight 1 by 4 board and plumb level are the best tools to establish the proper up-and-down working plane of the walking beam.

Loosen the center bearing holding bolts if correction is necessary, throw a line over the rear end of the beam and pull it into proper position, recheck with 1 by 4 and plumb level until true centering is attained, then tighten the center bearing holding bolts. If impossible to adjust, notify your maintenance crew for this is really important to concentric performance of the center bearing, equalizer bearing, pitman head joints, and wrist pins.

Lease & Well	First Day Premises	Second Day Alignment	Third Day Bolts	Fourth Day Counter Balance	Fifth Day Lubrication	Sixth Day Bbl per Day

Remarks & Recommendations:

Be sure wrist pins are not binding—loosen holding bolts slightly and run the unit several revolutions—then reset the holding bolts firmly. The horsehead should be very nearly vertical behind the wire lines at all positions of the full stroke length.

For maximum V-belt life the drive should be carefully lined up with the reducer.

Important to improved pumping unit service is constant security of all holding bolts. Foundation and all other holding bolts in the entire unit should be checked and tightened, if necessary, at least four times each year.

Counterbalances Protects Unit

Greatly important to the reducer design and even operation of the unit and subsurface equipment is counter balance. A rule of thumb field test involves disengaging the engine clutch or stopping the electric motor and watching where the cranks stop. If the cranks stop above the horizontal center line, the effective counter balance is insufficient and additional counter balance should be added.

If the cranks stop below the horizontal center line, the effective counter balance is sufficient. The peak torque rating of the reducer may be jeopardized if the effective counter balance is insufficient.

Lubrication Is All-Important

Recommendations of the manufacturer should be followed as closely as possible. Gear oil, oil, or grease should

EXCLUSIVE ***Planned programs of cleaning, painting, and lubrication will result in better equipment service, improved lease appearance, and lower lifting cost***

be checked as often as instructions specify. Lubrication of geared reducers is more critical and exacting than that of chain driven reducers.

Any accumulated water should be withdrawn from the reducer case at once and should be checked at least once each month. Required oil or grease should be added to the proper level if any appreciable quantity of fluid is withdrawn.

Oil in a chain reducer case should be changed and the case flush-cleaned at least twice each year. Roller or bronze bushed bearing chambers should never be more than one-half full. Excessive use of pressure type lubricating guns will rupture oil seals unless secondary oil plugs are removed during lubrication, or relief type fittings are installed.

Ruptured oil seals can cause costly bearing replacements. One manufacturer is offering pumping units with oilless center and equalizer bearings, oilless pitman head bearings, oilless wrist pin bearings, and oilless main shaft bearings after testing in field service. Also a simple new method is offered by this company to minimize the water condensation inside the reducer case.

Close attention is constantly given to the lubrication of an automobile. A pumping unit, which operates part time or 24 hours a day should have at least as much attention given to its lubrication requirements.

The Author

Some 35 years experience in engineering, production and manufacturing is behind F. W. "Rowdy" Robson, assistant to management of The Happy Company, Tulsa, Oklahoma. For 21 years he was in the engineering and production department of The Carter Oil Company. During World War II he spent four years in the pipe line and terminals division of Socony-Vacuum Oil Company. He has served in the engineering, manufacturing and sales promotion departments for the past 10 years.

Production Should Be Considered

A pumping unit should justify its initial investment, complete amortization, operating and maintenance expense, and still earn a reasonable profit. Very seldom is a pumping unit depreciated completely in 10 years, or 20 years. Many are still working good after more than 25 years.

Obviously this service will depend on proper selection of size to do the job at hand. No part of a unit should be stressed beyond its maximum rated capacity.

In order to determine the earnings of a unit, it is necessary to know the barrels of oil and water produced per day. Provisions for individual well testing will remove doubt as to which wells are paying off. For low barrelage wells, small containers and a watch can be used at the well head. A centrifuge test will provide the percentage of water.

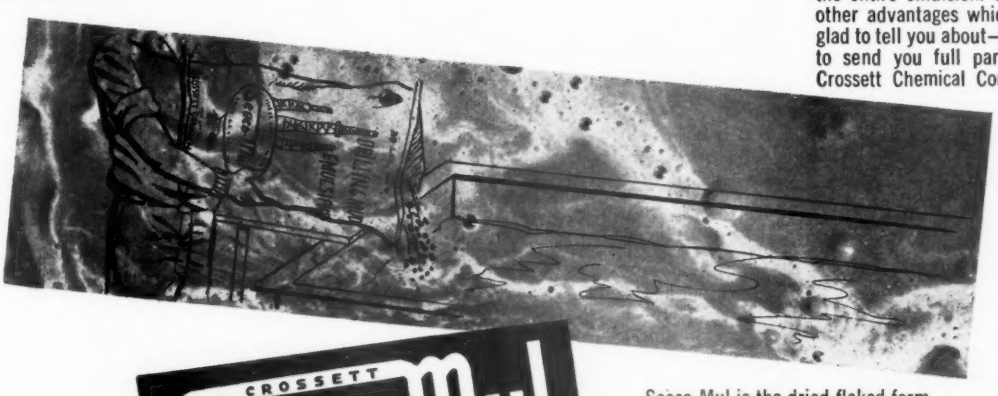
In order to protect the pumping unit and at the same time determine the gradual corroding or fouling of the flow line from the well to the storage tank, it is recommended that a pressure gage be installed in the production tubing head with a dampener between the gage and the tubing. Any increase in pressure is a danger signal.

The pumping unit is also a pumping station if any pressure exists in the production tubing head; 2.31 ft of additional equivalent fluid pumping depth for each pound of pressure. It is easy to see why the movement of the fluid from the well to the storage tank is an important factor in the proper maintenance of the pumping unit, as

Increase Drilling Rate With Less Drill Stem Torque

Better Lubrication • Lower Pump Pressure

Seeco-Mul effectively disperses the oil in emulsion muds which affords better lubricating qualities in the mud and allows faster drilling, reduces frictional drag of the drill string, and provides a higher velocity of the fluid on bottom. With good lubricating qualities in the mud, less drill stem torque is required, pump pressures can be lowered and more evenly sustained, and the bit stays cleaner. All of this means longer service life, too, for liners, collars, tool joints, bits, and drill pipe. Seeco-Mul is completely soluble in water and readily emulsifies Diesel or crude oils for use in sodium type or limed muds; in most cases Seeco-Mul efficiently tightens the entire emulsion. Seeco-Mul has a number of other advantages which your mud dealer will be glad to tell you about—or write to us; we'll be glad to send you full particulars without obligation. Crossett Chemical Company, Crossett, Arkansas.



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Seeco-Mul

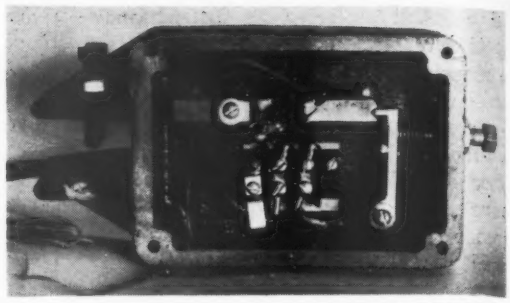
DRILLING MUD EMULSIFIER

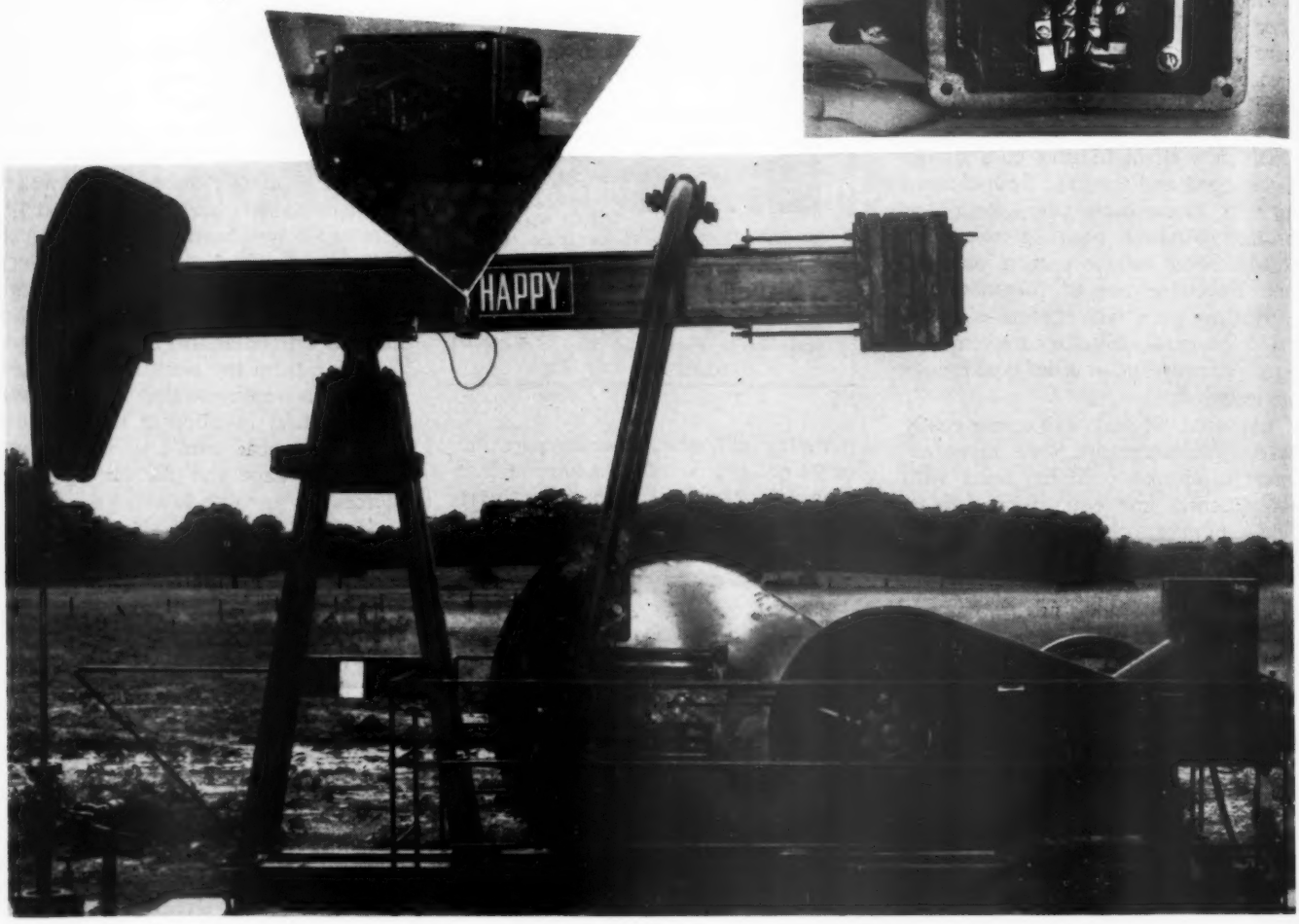
Seeco-Mul is the dried flaked form of so-called "crude floating soap," a compound of the sodium salts of abietic, linoleic, and oleic acids, together with quantities of wood tannins and lignins. Your own mud engineer can use Seeco-Mul without special instructions or equipment.

"MAKES A GOOD MUD BETTER"

To obtain more information on products advertised see Page E-41

Pumping unit in an Oklahoma oil field equipped with the "24-hour watchdog." The "watchdog" is attached to the underside of the walking beam and is designed to shut the well down automatically in case of mechanical failure. Insert picture shows operating mechanism.





well as knowing the barrels per day for economic analysis.

These are the most important categories in the maintenance of pumping units. All the assistance available from lease maintenance crews will make this or other schedules more effective. The more effective and orderly the schedule is executed, the nearer an approach and accomplishment of a producer's pride will be.

Other Actions Helpful

There are additional features in maintenance which will be helpful to pass on. Many refer to wells far removed from other wells as isolated. Geographically speaking this is true, but all wells are isolated when considered from the mechanical standpoint.

For instance, there is no pumping unit in operation anywhere that is constantly attended by a pumper. The pumper usually lives in the vicinity of his work but never stays a long period of time at any one well—and—he must sleep and eat. The pumping unit is performing constantly and is an inanimate piece of machinery. Therefore it doesn't tell the pumper of unseen conditions. Any mechanical failure of the surface or subsurface equipment may occur at any moment, usually, and luckily for humans, when no one is around.

When such events occur, the engine or motor will continue to run and the result may be a costly tear-up, unless an impulse, or shock actuated, shut-down device is used.

One of the most popular obtainable is mounted on the walking beam and the hook up is simple for either engine or motor shut-down. It serves as a constant watchdog for each part of every minute, 24 hours a day, day in and day out, year in and year out, at extremely low one cost insurance and assurance, in any kind of weather or temperature. The producer can eliminate worry, and save money if each pumping unit is equipped with one of these simple devices.

Another item of interest, neatness and good housekeeping—is paint. Even if a unit is wiped clean of all oil, it doesn't present good appearance if it needs paint.

Much more interest in caring for the unit is inherent in the pumper or maintenance crew if the unit has a good and pleasing appearance, just as a new or good-looking automobile holds interest. Paint up if the need is apparent. It may save accidents and it will pay off otherwise.

Perhaps the leases and pumping units are already up to par and you can't reduce your strokes. Here again may be a chance for improvement. If units are stroking more than 20 strokes per minute well pump efficiency may be low. The effective stroke in the well pump might be increased by slowing down the unit and still maintain production.

If this can be accomplished, the accelerated well load on the unit will be reduced and the unit will last many more years if it has been operating near or beyond its capacity. The less the number of strokes per minute, the lower will be the acceleration factor.

Guard the units properly for safety in accordance with safety codes, and guard the right to operate at the lowest, most reasonable cost. * * *

Shell Exploration in Venezuela

Rough terrain, lost circulation, and hard formations hamper Shell's wildcat wells in search for Cretaceous limestone production

SINCE the discovery by Shell of prolific light oil production — from Cretaceous limestone — in the La Paz field, which lies west of the city of Maracaibo, exploration has been particularly directed toward finding additional sources of limestone production. Since 1944 Shell has drilled a total of 26 Cretaceous exploration wells in an attempt to add to the light oil reserves and of these 26 wells 5 (i.e. DM-2, WT-2, C-148, S-5, C-151) have been successful.

With few exceptions all are more than 11,000 ft deep and include LS-1387, the deepest well in the world outside the United States, which bottomed in basement at 17,537 ft. The exploratory drilling following the La Paz discovery well has been successful in finding Cretaceous production in Mara, Sibucara, La Concepción, and also in West Tarra, the latter on concession of The Colon Development Company Ltd., an associated company of Compañía Shell de Venezuela.

Part of this exploration has been concentrated round the Mara-Maracaibo area which is fairly close to facilities, and where locations do not fall far from old field roads and operations can be supervised from existing camps. Quite a number of wildcats, however, have been spread more widely, necessitating the construction of many miles of new road, sometimes in very difficult and mountainous terrain, and the building and maintenance of wildcat camps far from machine shop and similar facilities, and from existing sources of material supply.

In particular, Well Conquistado-1 situated to the south-east of the Lake, was located on top of an anticlinal structure strongly expressed topographically by a sandstone hill over 2500 ft high. Drilling in the hard sandstone was extremely slow and continually handicapped by loss of circulation in the fissured formation. This was one of the most expensive wildcats drilled, the overall cost per foot being about twice the average figure.

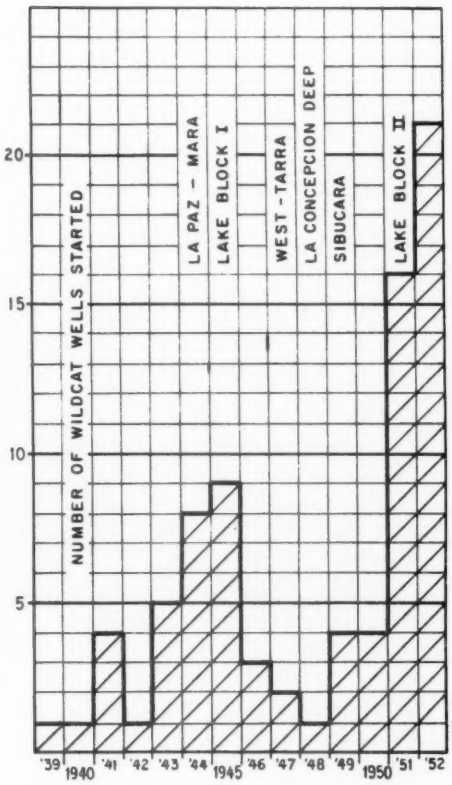


FIG. 1. Important wildcat discoveries by Colon Development Company, Ltd., and Compania Shell de Venezuela.

In one year, 360 rock bits of various types were used, giving an average penetration of 17.7 ft per bit. During the same period, in efforts to overcome lost circulation troubles, 15,000 sacks of cement were pumped into the well together with 400 tons of bentonite and large amounts of cotton-seed hulls, raw cotton, mica, bagasse, jelflake, Palcoseal, plaster of paris, and gunny sacks. Most of these efforts were unsuccessful and from 1600 to 3933 ft the hole was drilled by pumping water without returns.

In the case of both the Conquistado and the Misoa locations, difficult roads had to be constructed in steep terrain; and to the Burgua locations 180 km south of the Lake, some 45 km of road were built for the drilling of 2 wells.

Communication by road down the west side of Lake Maracaibo is possible only as far as a little south of Machiques; beyond here the unexplored country of the hostile Motilone Indians extends southward to the oilfields of Las Cruces and West Tarra. Transportation of personnel to and from Las Cruces is by plane, heavy supplies being brought up the Catatumbo River to Encontrados and from there by light railway.

The wildcat well 0-5 recently drilled on the Río de Oro has no access by road, and since the upper reaches of the rivers are not readily navigable in the dry season — which normally extends from November to March — heavy equipment has to be moved in as the river levels permit. The personnel for the Río de Oro well was lodged in a houseboat anchored on the river.

A good system of roads connects all the oil fields on the east side of the Lake, and communication across the Lake to Maracaibo is by commodious ferry boats. This road system ties in at Motatán with the trans-Andean highway which on its way through Mérida to San Cristóbal climbs to elevations of 13,500 and 10,000 ft over the Passes of Páramo de Mucuchíes and La Negra, a spectacular road with magnificent mountain scenery.

A new road linked to the Pan-American highway is now about 90 per cent complete; this runs on the flat land between the mountains and the Lake and when completed will facilitate transit between Valera and San Cristóbal and greatly improve communications between Colombia and Western Venezuela.

Exploration drilling in Western Venezuela has largely been guided by seismic surveys; and the development of the limestone fields of La Paz, Mara, and La Concepcion has been aided, as drilling progressed, by additional seismic lines and more detailed surveying. There has been close cooperation

EXCLUSIVE

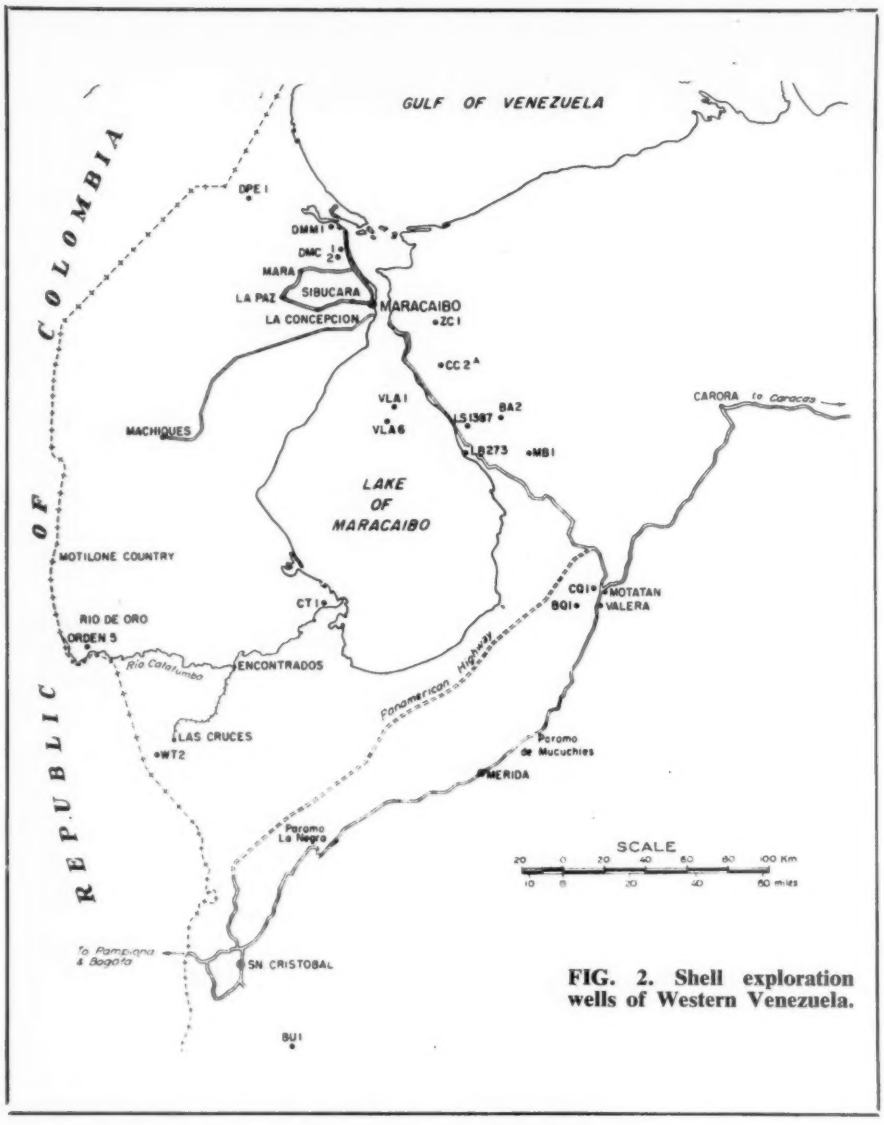


FIG. 2. Shell exploration wells of Western Venezuela.

TABLE 1. Important Shell wildcat wells in western Venezuela.

Well	Locality	Date spudded	Completed	Days	Depth in feet	Result
DM-2	Mara	12 Aug. '44	2 Mar. '45	172	6011	4600 bbl/day 29.50 API
CC-2A	East Cabimas	23 Aug. '45 (1)	22 June '47	779	15106	Suspended
VLA-1	Lake	2 Nov. '45	8 Nov. '47	737	12106	Salt water compl. Eocene
WT-2	West Tarra	19 Feb. '46	12 June '47	478	9173	4000 bbl/day 41° API
C-148	La Concepcion	28 June '46	20 Aug. '48	787	12085	1800 bbl/day 37° API
S-5	Sibucara	28 Aug. '47	13 Jan. '49	510	13451	10,000 bbl/day 37° API
LB-273	Pueblo Viejo	31 March '47	27 Nov. '50	1205	14746	Dry hole
ZC-1	Zamuro	7 Nov. '47	15 Oct. '49	709	14436	Suspended
CT-1	Boca Catatumbo	6 Aug. '48	27 Nov. '49	478	15638	Abandoned
DMC-1	Canadones	5 March '49	29 July '50	480	13392	Dry hole
CQ-1	Conquistado	8 Sept. '49	21 Dec. '51	837	11386	Dry hole
DMM-1	Mojan	1 Feb. '50	24 Nov. '50	297	11790	Dry hole
DPE-1	Escondillos	24 Mar. '50	22 Feb. '51	269	11231	Dry hole
LS-1387	Pueblo Viejo	12 Mar. '51	17 Sept. '53	911	17537	Dry hole
DMC-2	Canadones	2 Apr. '51	14 Jan. '52	288	10347	Dry hole
C-150	San Igancio	8 Mar. '52	15 Mar. '52	373	13210	Salt water
C-151	S. La Concepcion	25 Jan. '52	26 June '52	153	10886	7500 bbl/day 37° API
VLA-6	Lake	15 Aug. '52	27 July '53	215	10380	Salt water
BQ-1	Boqueron	27 Jan. '52	7 June '52	131	3059	Comp. Eocene
BU-1	Burgua	4 May '52	15 Feb. '53	287	8355	Abandoned
BA-2	Ballenato	27 Jan. '52 (2)	28 Nov. '52	500	13098	Junked
MB-1	Misoa	3 May '52	4 July '53	427	14046	Suspended
C-152	Lanudos	16 May '52	10 April '53	331	12450	Suspended
Average				494	11909	Dry hole

(1) Deepened from 4139 ft reached 31 Oct. '31
(2) Deepened from 7020 ft reached 14 March '46

throughout between seismologists and subsurface geologists. In general, seismic results are good and distinctive reflections from the Guasare limestone which occurs some distance above the top of the Cretaceous limestone are usually obtained. The Cretaceous limestone itself can often be identified.

The Cretaceous limestone is characterized by an extremely low average porosity and permeability, and production probably depends on the presence of fracturing and fissuring. The majority of exploration failures can be attributed to "tight" and unfissured limestone sections.

When fissuring is encountered, circulation is frequently lost; and production can usually be improved by acidizing. Many exploration wells with tight limestone have had repeated acid treatments, however, and attempts have been made to induce fissuring of the limestone by means of explosives; so far without success. Experiments have also been made using Hydrafrac methods to induce fracturing in tight limestone but the solution to this problem has not yet been obtained.

In the earlier limestone wells, attempts were made to plug off circulation losses with cotton seed hulls and similar materials, so that drilling could be carried on. As circulation loss usually denoted a potentially productive interval which might be plugged off, the use of such material was discontinued. In any case, it was found that circulation losses tended to decrease in course of drilling, by self-plugging of fissures with limestone cuttings and mud and since such material could later be removed by acidization, less permanent ill effects ensued. This suggested the control of circulation losses by dropping limestone chips down the hole, if sufficient quantities of cuttings were not produced by the drill.

An exploratory phase of remarkable interest has recently met with considerable success in the La Paz field. All the limestone producing wells in this field were taken to basement if circulation losses did not prove excessive, and the limestone section of 1800-ft thickness was usually produced barefoot.

Some cores at final depth showed the basement to consist of granitic and schistose rocks and occasionally the cracks in these contained oil. There seemed to be no reason why, if the basement were fractured in depth, it might not also prove to be oil bearing. Furthermore, the possibility of basement reservoir at La Paz was also suggested by material balance calculations. One of the older wells at La Paz was therefore deepened over 1000 ft into the basement, and has been producing 3000 bbl per day of light oil from fractured granitic rocks for several months.

A wildcat well of considerable interest was drilled in 1948/49 on concessions of The Colon Development Company near the mouth of the Catatumbo River. This was an extremely isolated location situated 100 km from the nearest drilled well, and lying in an area of extensive swamps, making it difficult of access. Preparations for

drilling involved the building of a dyke around the location and the setting of the foundations on a concrete mat. Drilling was relatively rapid to the final depth of 15,638 ft (which for a time was the depth record outside the United States), although progress was hindered by time lost owing to transport difficulties to this isolated site.

Table 1 shows the depths of some of the more important wildcat wells drilled by Compañía Shell de Venezuela and The Colon Development Company Ltd., and the location of these tests is shown on the map (Fig. 2). The area explored is widespread but the areas of success proved by these deep wildcat wells are confined to the west of Maracaibo, to an area in the southwest of the Lake and to deeper Eocene discoveries in the Lake itself. The percentage of success is however relatively high, 7 of the wells out of the tabulated total of 23 wildcats finding production.

The length of time spent on some of the deep wells is usually due either to the difficulty of drilling the compact Eocene formations or to bad caving in underlying shales. This last was largely responsible for difficulties in LB-273, which had 4 sidetracks below 10,000 ft before reaching final depth.

* * *

Tidelands Oil Expensive

The economic risk assumed by the oil industry in drilling for oil in the Gulf of Mexico has been revealed by Ira H. Cram, senior vice president of Continental Oil Company. He reported that more than $650 million has been spent within the past 10 years for exploration, drilling and development, with a financial return estimated at only $110 million, or less than 20 per cent of the investment. He pointed out that the industry is prepared to invest even more millions, subject to favorable economic conditions and favorable government attitudes.

"If there ever was a place where lessening of the time-tested incentives —including the depletion allowance— would surely dry up the supply of oil and gas, the offshore is that place," he warned. "Furthermore, any lack of statemanship in the agencies determining production allowables would dry up the supply."

In revealing the immensity of the financial risks taken to develop oil and gas production from the offshore regions, Cram told API members at the Southwest district meeting in New Orleans that the $650 million investment in the tidelands is far more than the annual total value of all the farms crops raised in Louisiana.

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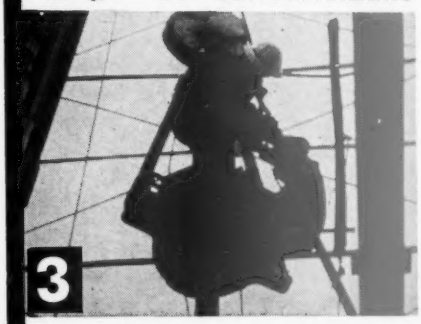

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. . . ANOTHER TRIUMPH IN
APPLIED PRACTICAL IMAGINEERING

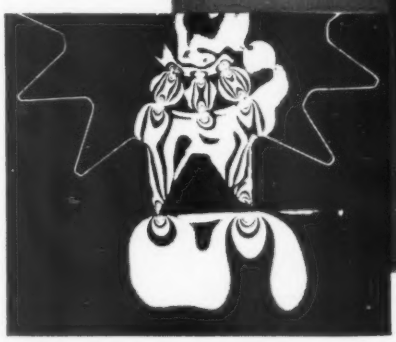
..seeing the un-see-able

THE PRESIDENT OF A MAJOR OIL COMPANY HAS SAID:
"It is as impossible to give the greater credit for petroleum's magnificent progress to either the oil operators or the fabricators of their equipment, as it is to say whether the hen or the egg came first."

Astounding technological progress by the petroleum manufacture-supply-service industry is the reason for many statements of praise regularly being made by top men in the petroleum industry. More than 9000 research scientists and engineers are constantly surprising their great customer, the gigantic oil industry, with amazing new methods for inventing and improving equipment and services.

One of the most interesting of these new techniques enables an engineer to observe stress concentrations which simulate those set up by the drilling bit in a formation being drilled. Versatile and resourceful engineers, knowing the photoelastic properties of certain plastics, sought to use this knowledge to make stress concentrations visible in the formation at the point of drilling. Like the applying of most other general theories, this technique was not easy to work out in practice. But after innumerable trials in the preparing of the plastic model and the development of skill with such types of apparatus as the polariscope, polarizing filters, analyzers, and special cameras, it became possible to produce good pictures showing stress concentration in a manner that is of great diagnostic value.

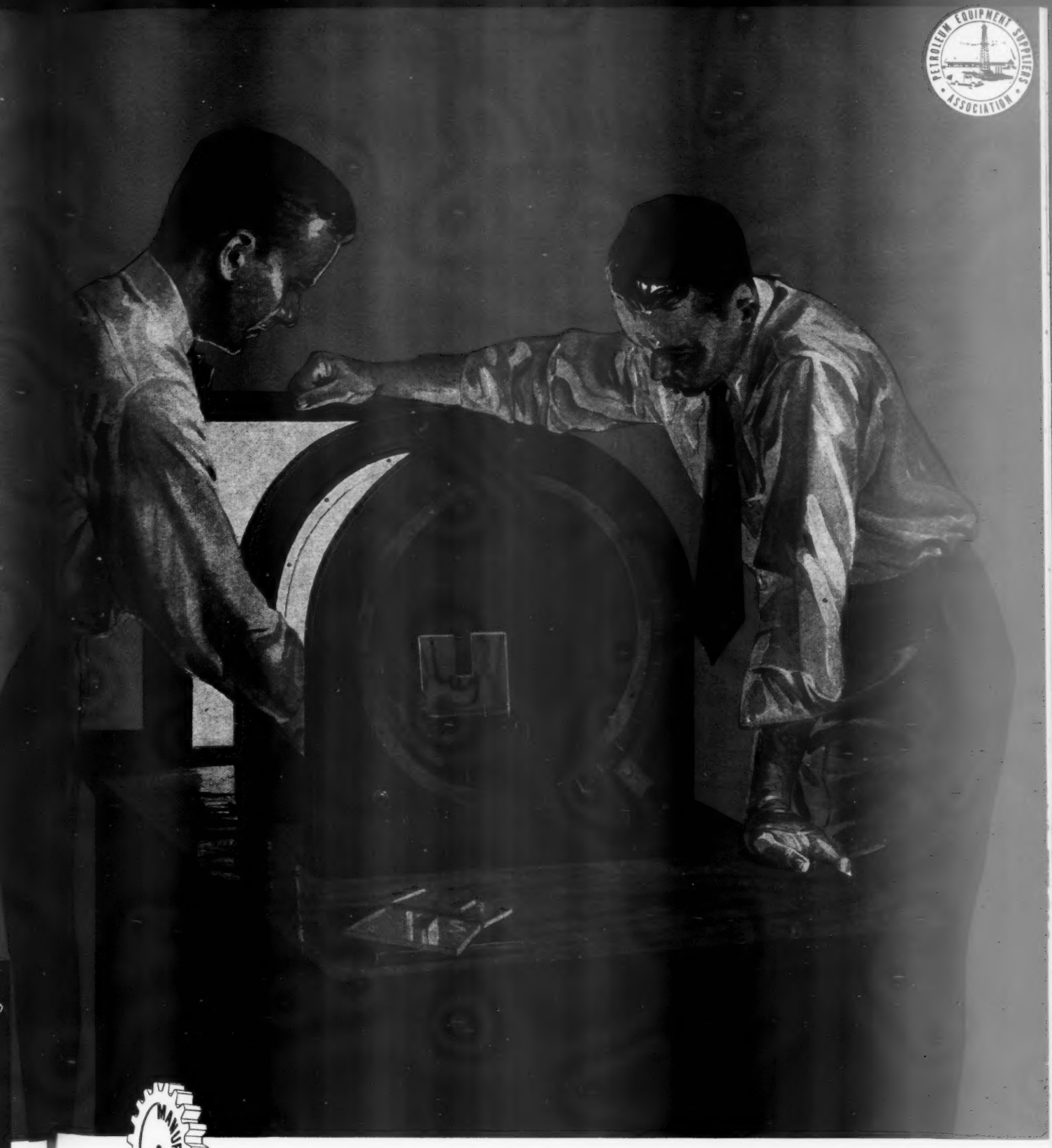
The vision of P.E.S.A. members knows no horizons. More scientists, research engineers, development engineers, and field engineers are being added to the over-9000 already making noted accomplishments through aggressive adventurism. P.E.S.A. members are determined to be a teammate that carries its full load, along with oil company technologists, for advancing at an even greater rate the progress of one of the world's most dynamic industries — and, from the standpoint of strength and security of our nation, one of the most *important* — OIL.



A new technique, using photoelasticity, makes possible the study of stress concentrations which simulate what takes place in an actual drilling well.

Heretofore it was possible to study and analyze worn bits on the laboratory table — and such studies confirmed or disproved many a complicated mathematical projection on stress concentrations. But until the development of photoelasticity and techniques for applying it to practical problems, there was no way to study adequately the stress concentrations set up in the well formation itself by the action of the drilling bit. Now a plastic facsimile of the drilling well can be placed on the laboratory table. Here the stress concentrations similar to those which occur in well formations can be **seen** and studied.

XUM



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COMMUNICATIONS

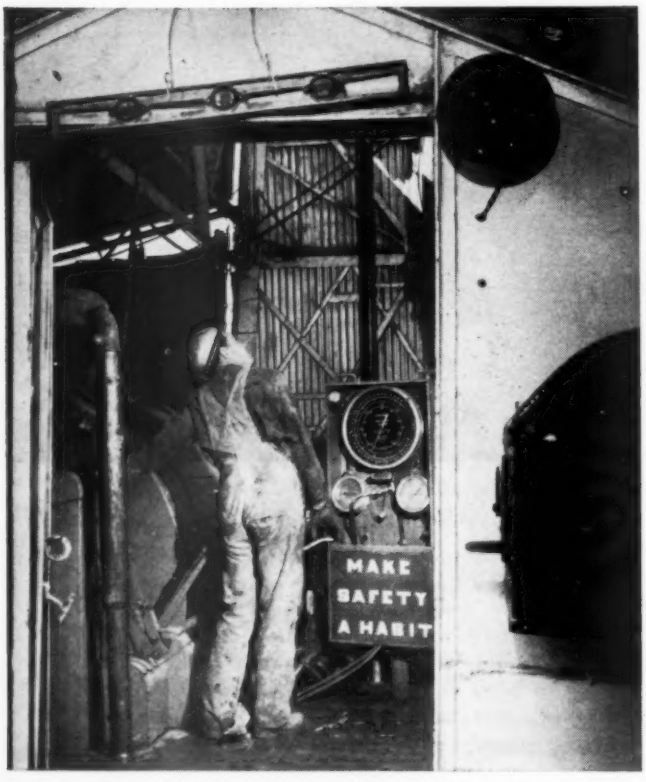
W. R. Harrington*

MAN has always had the need for communicating with his fellow man and his advances in civilization have been directly affected by his ability to express himself and exchange ideas. Today, our standard of living makes a constant flow of messages vital to our comfort, well being, and personal progress as well as creating a demand for speed and clarity in our economic life.

The drilling industry has all the same requirements of communications that may be found in the business world in general with a few added needs that cannot be met by ordinary methods. These everyday means of transmitting messages include such familiar means as our postal system, telephone, telegraph, and personal contact and are so widely used in our personal life as well as in the control and direction of industrial operations that an explanation of them would be superfluous.

The drilling industry has special needs and the modern facilities with which to cope with them. Oil wells must be drilled at remote locations wherever the geologist indicates there is a probability of finding commercial production. At many such remote areas communications are tied to the relatively slow speeds of the transportation available. Automobiles are often hampered by bad roads and extreme distances and air transportation may be ruled out by lack of landing area or weather. At the same time, more and larger equipment, deeper drilling, and the economic necessity for speed are all making direct communication essential to provide information to the proper persons wherever they may be and to return decisions to the field for execution. The answer to the widespread operations of the drilling industry lies in the medium of radio and radio telephone.

*Gardner Brothers Drilling Company, Dallas, Texas.



Radio loudspeaker is mounted at right top of doorway in driller's dog house. Driller is at drawworks.

Within the past 10 years the rugged FM (frequency modulation) radio equipment has come to the fore in drilling operations because of its suitability for the severe operating conditions of drilling rigs and mobile use. This equipment when installed on drilling rigs, in toolpushers' cars or houses, in mechanics' and superintendents' cars, trucks, and at centrally located offices provides a network of instant contact linking operations and personnel for efficiency.

A few of the more important advantages of radio being used in the drilling industry are:

1. **Less "down-time" on the drilling rig. Trouble may be reported immediately and supplies or service personnel dispatched to the drilling site promptly.**
2. **Eliminates unnecessary mileage on cars and trucks.**
3. **Reduces waiting time at the location for trucks, service personnel, etc., by ordering them out at the proper time.**
4. **Allows toolpusher to devote his time to supervising instead of driving miles to a phone.**
5. **Permits the drilling superintendent to contact the toolpusher with new orders or to change orders without delay.**
6. **Performs a service to the "customer" by relaying orders quickly and helps the representative of the company complete his work.**
7. **Promotes employee relations by maintaining an indirect contact with his family for emergency messages.**
8. **Maintains a constant link with aid for emergencies such as injuries, fires, blowouts, etc.**

Mobile telephone service which the telephone companies have established in certain areas is perhaps the simplest use of radio in the drilling industry. With radio telephones installed in automobiles a drilling company has no investment since the sets are leased from the telephone companies. This mobile service is usually limited to a range of 25 miles from the nearest telephone company receiving tower. An operator on duty at the receiver will connect the subscriber to the telephone system and he may talk to any telephone. Charges are made to the subscriber at a flat fee for a specified number of calls and an additional charge per call after that plus any long distance toll charges that are made. The disadvantages of the system are that the user must be fairly close to a receiving tower, and it must be shared with many other types of users. This means that in a congested area the user may have to wait a considerable period of time (up to several hours), before he may use the channel to which he is assigned.

The most popular type radio used in drilling operations is the privately owned two-way radio system. The drilling company owns its own equipment, on the rigs, at the offices, and in cars or trucks, and may talk between any of them whenever necessary. Other companies may be using the

XUM

Driller at rig radio talks to office and to foreman in car.

same frequency but the Frequency Coordinating Committee of the National Association of Petroleum Radio Users attempts to minimize interference by allocation of channels in any one area. Even where two or more companies must use the same frequency in overlapping areas due to the limited number of channels available, interference is not a major problem where all parties observe the Federal Communications Commission regulations and the rules of everyday courtesy.

The basic radio system of a drilling operation consists of a rig set and a mobile set installed in the toolpusher's car. This allows the toolpusher to stay in constant touch with his operation, to supervise even when he must be away from the rig, and to save himself miles of unnecessary driving. A special remote control unit is available which plugs into the car set enabling him to send and receive messages from his bedside during the night when he is at home. The effective range of this combination, car to drilling rig with antenna atop a 130-ft derrick, is approximately 35 miles. When a company operates a number of units within a 60 to 100-mile radius, it often installs a base station at the field office. A remote control may be installed in the drilling superintendent's house in order to use the station if the office is closed at night. The central base station may also be controlled from a distant point by means of radio relay. This type of operation allows extended ranges when the office is not in the center of the area of activity.

Since one of the major factors in the distance a station may be useful is the height of the antenna, this central radio station should have as high a mounting for the antenna as is practicable. Many companies are using sections of pipe or an old derrick as a tower while others prefer a standard radio tower because of its increased height. Tower space may sometimes be rented on the existing tower of some other company if the transmitters do not interfere because of assigned frequencies.

Drilling reports, orders, requests for supplies or services, etc., can be sent from the rig or car directly to the office and it allows the superintendent to keep up to the minute with all developments as well as plan company wide operations effectively. The radio system for a drilling company can be as flexible as its needs demand. Base stations are more or less permanently fixed as in field offices, but the temporary base stations (drilling rig radios) may be moved at will within the area prescribed in their licenses and, of course, the mobile units may operate anywhere within the area to match the movement of the rigs.

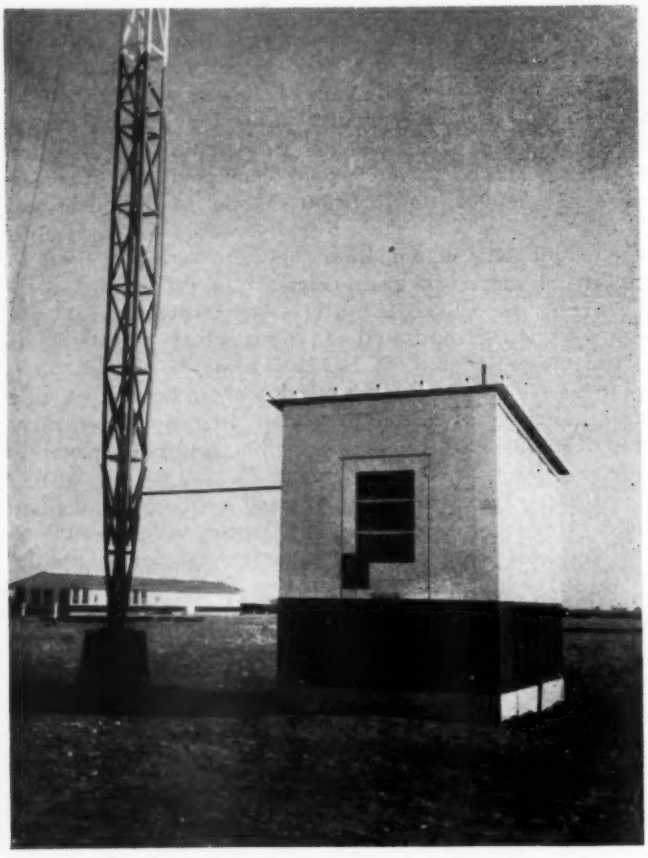
An operator may elect to start a radio network with only a few stations or units and add to his system one station at a time as he needs them. For this reason he should anticipate his needs and apply for the number of licenses he feels will ultimately be used in his system. In some areas a number of smaller operators are using one control base station under a cooperative arrangement.

All radio stations must be licensed by the Federal Communications Commission and the licenses may be obtained without cost upon proper application showing eligibility. The Petroleum Radio Coordinating Committee will issue the user a frequency recommendation which the FCC will consider when assigning a given channel to the user. In most cases, the seller of the equipment to be used will aid the user in the preparation of all the applications and will follow the proceedings until the proper licenses have been obtained.

The drilling industry falls in the category of "Petroleum Radio Service" which is limited to those defined as "being in the business of prospecting for, producing or transporting petroleum and petroleum products." Oil field service and supply companies, along with construction companies are licensed in a separate group known as the Special Industrial Radio Service using different frequencies than those of the Petroleum Radio Service.

Theoretically, FM radio signals travel in a straight line and are therefore limited to a "line-of-sight" distance between transmitter and receiver. Actually, the effective range more nearly approaches double the "line-of-sight" distance due to bending or the tendency of the signal to curve around the earth's surface.

Radio installed in car trunk for mobile connection.



Radio transmitter building for field office installation showing base of antenna tower.

The following are some approximate ranges of the radio equipment being used in the Southwest for operation in the Petroleum Radio Service band using 50-watt station and mobile sets:

Mobile to mobile	15 miles
Mobile to drilling rig (130' ant.)	35 miles
Rig to rig	50 miles
Rig to base station (180' ant.)	60 miles
Rig to base station (280' ant.)	70 miles
Mobile to base station (180')	40 miles
Mobile to base station (280')	45 miles

These are average figures for flat terrain and it must be remembered that the power of the equipment, the electrical noise level, (electrical noise level in the vicinity of the receiving station such as noisy electrical transmission lines, etc.), the terrain to be covered, and the weather all have a marked influence upon the effective range. In many cases the range is considerably greater in certain directions and under ideal weather conditions. These averages are the approximate ranges which the manufacturers consider their equipment will perform with reliability.

In order to increase the range of a station, any one of several things may be done or all of them may be done. An increase of the base station transmitter power is often used to increase the "talk out" power which will help override the high noise level which may prevail in the vicinity of the receiving station or mobile unit. Another method is to have a directive antenna which will "focus" the coverage over a specific desired area. Installations are available where the operator can control the direction at will from a remote position. Maximum range may be had by proper selection of the antenna site, using the maximum antenna height practicable, using increased transmitter power and by the usage of directional antenna.

Under certain atmospheric conditions freak, greater-than-normal ranges may be had due to bending and skip. These conditions, however, while advantageous, are not dependable and should not be considered in the design of a system.

There are several leading makes of radio equipment available which will ably serve the needs of the drilling industry. The operator should be careful in selection of equipment and perhaps even more careful in the selection of his radio engineering service company. Most companies have found it economical to enlist the aid of one of these service companies to aid them in preparing applications, selection and design of equipment, and maintaining the system after it is in operation.

The equipment itself, in addition to being rugged and reliable, should be designed for easy moving. Most sets are mounted in a compact steel case which can be carried by two men and moved in the seat of a toolpusher's car. All connections from the antenna and power supply should be of the "quick change" type and should be designed so that wrong connections cannot be made. This will eliminate error and makes it possible for drilling crews to install or remove the sets without a service engineer. Mobile units can be installed in any make car with a minimum of damage to the car and most sets are very similar in design of exterior appearance and size.

With the cars now on the market being equipped with 12-volt electrical systems it would probably be wise to determine that all new mobile units purchased be capable of operation on 12 volts. A base station may have a variety of accessories such as microphones, speakers, and remote controls in various offices to fit the individual needs of the user. Rig radios may be equipped to operate several ways depending upon the power source at the rig.

Cost of the equipment itself is about the same whether it be for a constant supply source or battery operated set, but the maintenance is somewhat higher for battery operation due to the battery and its charging system.

Most users in the drilling industry have found it expedient and economical to have their maintenance performed for them by an outside maintenance company. Usually this contract service is provided at a flat-fee, per-unit rate, which includes labor, tubes, parts and mileage. It may be handled through contracts with local companies in the areas in which the units are located, or with a single company which specializes in service to the entire oilfield area.

Cost of a radio system may be approximated by adding the cost of the component parts listed below. These prices are indicative of the installed prices being quoted in the Texas oilfield areas.

Mobile units (60 watts)	$ 600.00
Rig base stations (60 watts)	1,000.00
Base station less tower (250 watts)	2,000.00
Antenna tower lighted (180')	2,200.00
Antenna tower lighted (280')	3,400.00
Directive antenna for rig	200.00
Rotating directive antenna on tower	1,500.00

These are the "investment costs" of the equipment but most operators who have used the radios are now thinking more in terms of "savings instead of costs." Based on 5-year depreciation and current maintenance prices, a complete system of 6 drilling rigs, 8 mobile units, and one field office station would cost about $3 per day per rig, when charged to the rigs. At the high cost per hour of a drilling rig, it is necessary to save only a few hours to change the "cost of radio" to "savings by radio" without taking into account the savings in automobile mileage and the increased efficiency of the overall operations.

Truly, radio is the bright light in the field of communications for the drilling industry.

In Reservoir Studies

Pressure Build-up Curves Show Oil-in-Place

Here the concept of use of the data is developed and practical applications for the solution of several reservoir problems is presented

J. Randolph Buck

THE subsurface pressure build-up curve is one of the most significant, yet least understood, characteristics of a producing well. The curve is basically important since it describes the relationship of the well to the surrounding reservoir. All of the recognized properties of the reservoir rock and its contained fluids contribute to the curvature observed during the transient, or unsteady state, conditions existing during the pressure build-up interval.

Initially the pressure build-up curve was utilized primarily to obtain the true formation shut-in pressure. More recent investigators have subjected the curve to rigorous analytical treatment for the calculations of such reservoir properties as average permeability, average pressure in the drainage area, and localized pressure drawdown adjacent the well bore. Although porosity appears as a factor in some of these works, it is often appropriately bound to and difficult of separation from such other factors as "dimensionless time." It has been the purpose of this investigation to approach the build-up curve from a different angle in order that porosity, an important factor in its own right, be not so complexly obscured.

Consider a well where, typically, very little drilling and test data are available. The well was logged conventionally, so there is a fair idea of the net pay thickness. The need of running productivity index and pressure build-up tests, then determining from these limited data the barrels of active oil in place per acre becomes highly intriguing. Through use of a simple analogy and Darcy's Law, an algebraic expression can be derived to establish the proportionality between porosity and build-up time when taken together with the usual volumetric and flow parameters.

Actual field data where porosity is known can then be applied to this relationship for the development of useful correlations from which a realistic evaluation of the active oil in place can be determined from net thickness, productivity index and build-up data for wells where effective porosity is not known. The significance of actual build-up time, the analogous system, and the analytical treatment that may be given the build-up data under the concept of an equivalent exponential curve are discussed in the following. Build-up data, when subjected to this type of analysis, can be employed in the determination of connate water, permeability cut-off, fraction volume and in other practical uses that are suggested. The basic concept and the potential applications and limitations of this type of approach are discussed in the following.

Actual Build-Up Time

After a producing well is shut-in, reservoir fluid continues to flow into the pressure tank, thereby compressing the expanded fluids near the well and eventually restoring the bottom-hole pressure at the well to the so-called static pressure of the reservoir. The elapsed time for this process to be completed is dependent on:

1. The average pressure drawdown in the drainage area,
2. The compressibility of the flowing fluid
3. The volume of space to be filled during the process of compression, and

EXCLUSIVE

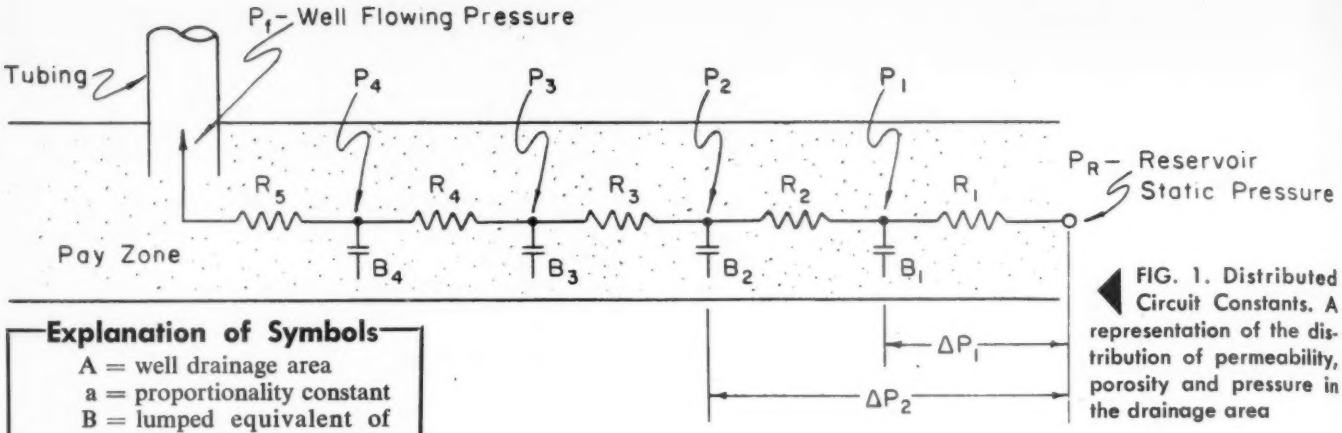


FIG. 1. Distributed Circuit Constants. A representation of the distribution of permeability, porosity and pressure in the drainage area

Explanation of Symbols

- A = well drainage area
- a = proportionality constant
- B = lumped equivalent of the total volume of fluid that moves into the drainage area to restore pressure to the static value
- b = proportionality constant
- β = formation volume factor
- c = compressibility factor
- d = porosity distribution factor, assumed constant for radial systems
- d_n = porosity distribution factor applicable to an incremental annular compressible volume for its conversion to the equivalent volume lumped at the well. (d_n approaches 1.0 at the inner ring and zero at the outer ring)
- h = net thickness
- k = average effective permeability in drainage area
- μ = viscosity
- P_R = shut-in reservoir pressure
- P_f = flowing bottom-hole pressure
- P_n = pressure at any given radius from well bore
- ρ = instantaneous bottom-hole pressure
- $\triangle P_n$ = average pressure drawdown on an annular ring
- $\triangle P_{av}$ = weighted average pressure drawdown for entire drainage area
- P.I. = productivity index
- f = average porosity in drainage area
- f_m = matrix porosity
- R = total resistive effect impeding the flow of fluid in the formation
- r_e = drainage radius
- v = drainage radius
- x = fraction of total net saturated thickness represented by fracture volume
- t = chronological time from p = o

4. The mobility of the fluids that governs the rate at which the replacement fluids can enter the sink for the purpose of restoring the pressure to the static value.

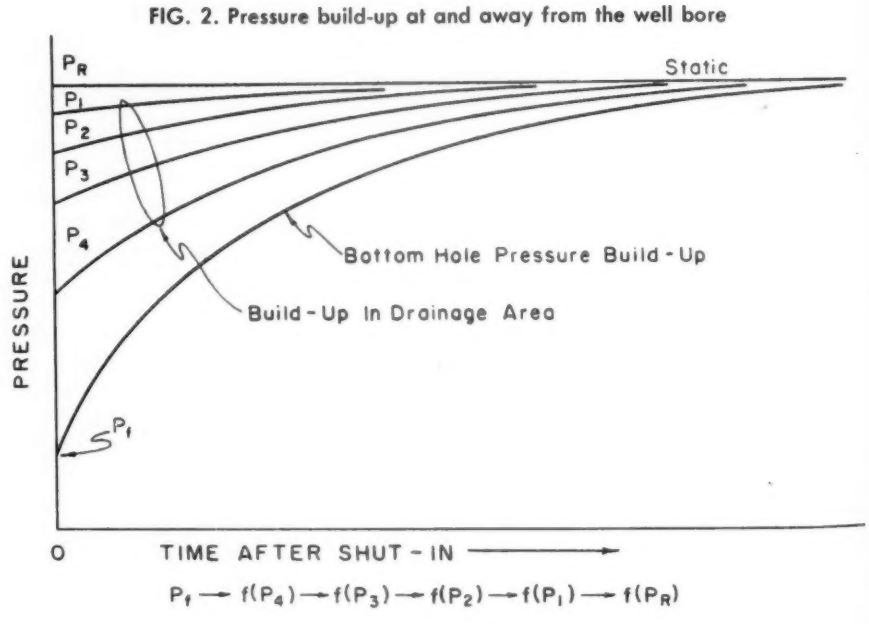
To illustrate the dependence of time on these four generalized parameters, it is apparent that, other factors being equal, the build-up time for a high porosity (large volume) well will be longer than for a low porosity well, since there is more space to be filled at the given rate of fill-up. Another case is that, other factors equal, a low permeability reservoir will take longer to reach static pressure than would a more permeable formation, since for a given space to be filled the required volume of equalizing fluid must traverse the sink more slowly in the tighter pay.

In brief, there is but a limited number of reasons why a given well displays a long or a short build-up time. They all relate to the general flow characteristics of the rock and the fluid, the pressure difference causing flow, and the bulk volume to be filled. From the productivity index tests one obtains a convenient integration for the overall effect of these rock, fluid and pressure properties under steady state conditions. With build-up time being a measurable quantity after shut-in, the only remaining unknown is the fill-up volume which is a function of drainage area, net thickness and porosity. An approximate solution of the problem is available through consideration of an electrical analogy.

Electrical Analogy

Fundamental work leading to the development of the Carter-type reservoir analyzer has demonstrated that the current flowing in a resistance-capacitance network can be brought into proportionality with the flow of fluid in a permeable, porous medium. In such studies voltage is proportional to pressure, current is proportional to the rate of fluid flow, resistance is a function of the permeability of the medium and the viscosity of the fluid, and capacitance relates to formation porosity and the compressibility of the flowing fluid.

FIG. 2. Pressure build-up at and away from the well bore



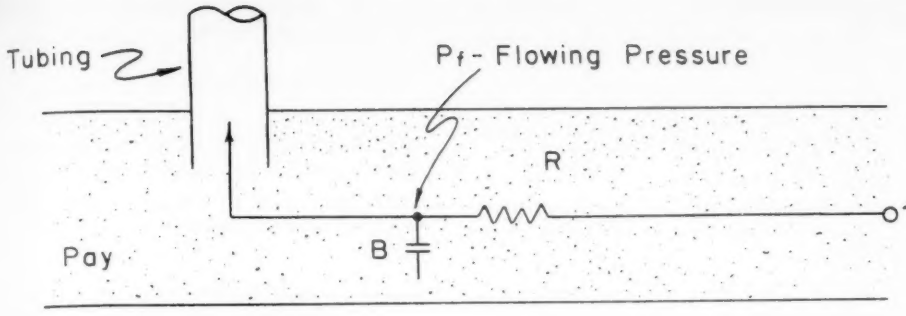


FIG. 3. Lumped Circuit Constants. The concept of a well system considered as an equivalent condenser, B, charged through a series resistor, R, from the source, P_R

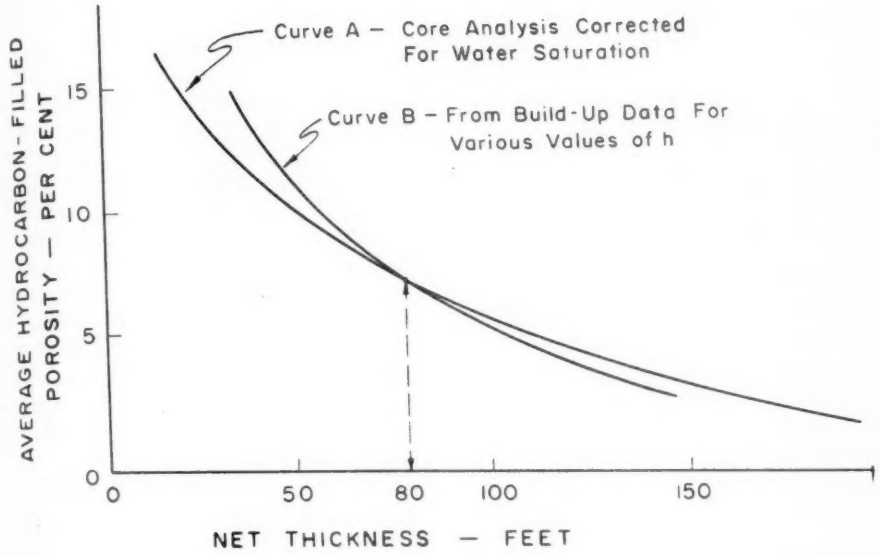


FIG. 4. Determination of effective net thickness. The intersection of curves A and B represents the true value of effective net thickness

All elements can be chosen for the analyzer such that past performance of a given reservoir can be duplicated and future performance predicted. The significance of these electrical circuit elements is retained in the following treatment.

If a single well system be considered, the equivalent circuit for radial flow can be represented approximately by an electrical transmission line characterized by distributed resistance and capacitance as shown in Fig. 1. In this figure P_1, P_2, etc. are pressures existing at various radii from the well bore. R_1, R_2, etc. reflect the average permeability-viscosity factors at these radii. B_1, B_2, etc. have the significance of fill-up volume-compressibility relationships applicable in each of the annular rings. $\triangle P_1$, $\triangle P_2$, etc. are the average pressure drawdowns of the volumetric rings.

Fig. 2 shows the generalized pressure distribution existing at the points P_1, P_2, etc. under flowing conditions and at any time after shut-in.

Because of the distributed nature of the circuit elements, the pressure build-up curve applicable to any point depends on the pressure behavior of all other points. For example, the pressure at P_3 at all times is lower than at P_2 and is higher than at P_4. If the storage capacity of B_2 is high (as by a local fracture system) pressure P_2 will remain relatively low at a given time during the build-up and this effect is reflected to P_3, P_4, etc. which lag behind the response of P_2.

In this manner the pressure build-up observed in the well itself is the result of the permeabilities and storage capacities existing successfully all the way out to the outer boundary of the drainage area.

For practical purposes we are concerned with knowing the total effective value of B rather than the variations exemplified by B_1, B_2, etc. To achieve this end, it is essential to consider the applicable fraction of the total compressible volume in the drainage area which, when concentrated at the well, would reflect the same build-up time when replenished through the total resistance, R, extending from the well to the outer boundary as would the total compressible volume when normally distributed and replenished through fractional values of R.

Except for highly irregular areal distributions of permeability and porosity the fractional compressible volume, B, is related to the total compressible volume through a constant of proportion-

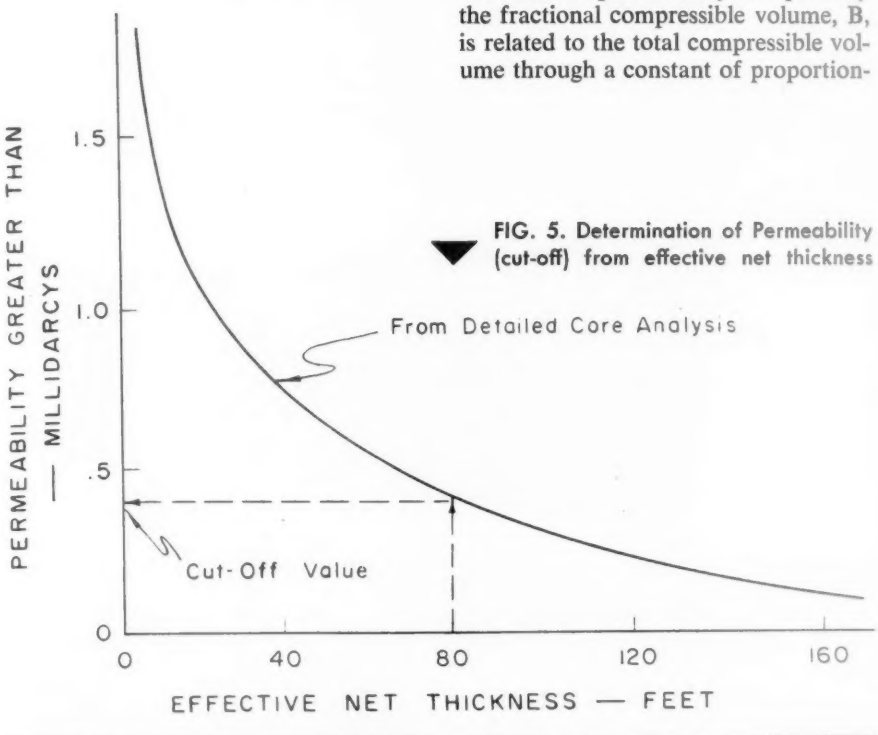


FIG. 5. Determination of Permeability (cut-off) from effective net thickness

ality dictated by the geometry of the flow system.

In equation form we have:

$$R = R_1 + R_2 + \ldots + R_n \cong a\left(\frac{\mu}{kh}\right) \ldots\ldots (1)$$

$$B \cong d_1 B_1 + d_2 B_2 + \ldots + d_n B_n \cong b\,d\,A\,h\,f\,c\,(\triangle P_{av}) \ldots\ldots (2)$$

where a and b are constants for dimensional conformance, and d is the weighted average porosity distribution constant.

Equation (1) results when one considers that the fluid flowing during pressure build-up moves a distance equal to the drainage radius, r_e, through an average cross-sectional area given by $(\pi r_e h)$ in a medium described by the expression $\frac{\mu}{k}$. In the field terms R has the general significance of pounds drop in pressure per reservoir barrels of oil per day, or the reciprocal of productivity index corrected for reservoir barrels.

Equation (2) is an expression defining the fractional or equivalent fill-up volume. In accordance with the simplified arrangement given in Fig. 3, bottom-hole pressure would demonstrate a true exponential characteristic on build-up test.

Exponential Equation

Assume the well system of Fig. 3 is ideally produced at its theoretical maximum rate where the bottom-hole pressure is zero, then is shut in at the sand face. The presssure would rise in accordance with

$$\rho = P_R\left(1 - e^{\frac{-t}{RB}}\right) \ldots\ldots (3)$$

At the instant when $t = RB$, then

$$\rho = P_R\,(1 - e^{-1}) = 0.632\,P_R \ldots (4)$$

Accordingly, when the subsurface pressure is 63.2 per cent of the static value, then the time from $\rho = 0$ to $\rho = 0.632P_R$ is equal to the product of R and B. This is the one instant of direct, linear relationship between build-up time, permeability, and porosity.

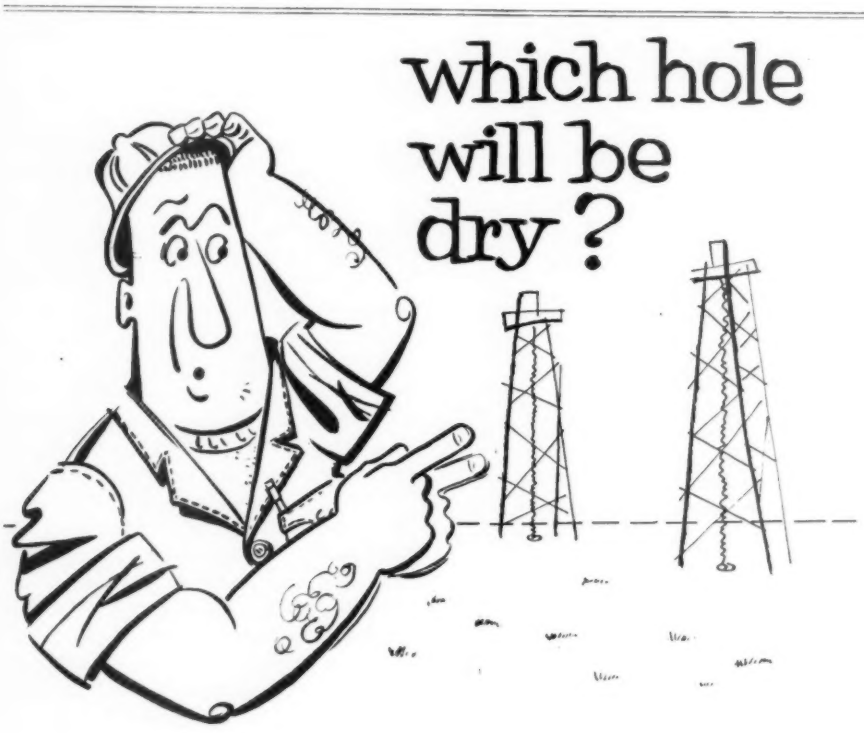
A well under normal flowing conditions is not producing at zero bottom-hole pressure but rather is equivalent to a partially charged condenser in the electrical analogy. The shut-in hours as recorded in the field relate only to the time elapsed after the final instant of flowing pressure, whatever value it may have been.

The field data provides information leading only to the tail end of the equivalent exponential curve which theoretically starts when $\rho = 0$ rather than when $\rho = P_1$. The initial values on the equivalent exponential curve never actually occur, and it is indeed fortunate that they do not, since other physical effects would completely destroy the validity of the analogy. The alternative in their determination is to select two representative points on some consistent basis from the "straight line" portion of the build-up curve on semi-log plot and to allow them to define the complete equivalent exponential curve for the well, hence the hypothetical time when $\rho = 0$.

In this manner actual time as recorded in the field measurements can be corrected to indicate calculated time for the well pressure to rise from zero to 63.2 per cent of the static value.

It is important to observe that the equivalent exponential is constructed from data obtained during that portion of the build-up period when well bore fill-up and other localized effects have subsided. The section of the curve considered useful for calculating average permeability in the drainage area is, accordingly, appropriately applied in the determination of the equivalent exponential curve.

Since the so-called straight-line section of the build-up curve is straight only for practical purposes rather than by theory, it would appear equally



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justifiable to fit the data in this region to the exponential form.

Correlation With Field Data

Equations (1), (2), and (3), when taken together with Darcy's law for single phase fluid flow, provide the basis for algebraic manipulations to eliminate the introduced factors, B and R, and to solve for porosity in terms of the other factors. Remaining terms are those commonly employed in reservoir studies with the exception of time, t, which is with respect to the time when $\rho = 0$ as previously described.

In all cases porosity can be set equal to an expression, the number of terms in which is dictated by the extent and quality of the data available and by the number of simplifying assumptions that are justified. The writer has found the following assumptions to be useful under certain circumstances and conditions:

1. Variations in the log of the ratio of radii are negligible.
2. Average pressure in the drainage area is proportional to bottom-hole flowing pressure under steady state conditions and is inversely proportional to the drainage area. In effect, the product of drainage area and average drawdown is a constant for a given well producing at a given rate; consequently, the drainage area arbitrarily assigned to a given well is not at all critical with respect to porosity determination for the reason of the compensating effect of average pressure drawdown.
3. Radial flow applies in the drainage area.
4. The effect of the compressibility of the reservoir rock and of the interstitial water can be neglected over the range of drawdown pressures usually encountered.

The writer has not undertaken a direct solution for porosity but rather has plotted various functions derived from the controlling relationships against oil-filled porosity for those cases where relatively complete and high quality basic data from several different oil fields in different provinces under favorable conditions were available.

Correlations to date have substantiated the concept of the equivalent exponential curve and the restricted use of simplifying assumptions. Based on experience to date the calculated probable deviation between oil-filled porosity through use of correlations and oil-filled porosity obtained from core analysis when corrected for interstitial water saturation is on the order of 1.5 percentage points of porosity.

Only the completely non-conforming wells to be mentioned later were omitted from the error calculation.

Applications

Interpretation of the pressure build-up curve in the manner described has a number of practical applications, some of which are unique.

1. **Fractured formations.** From the standpoint of the build-up curve, porosity is a measure of the bulk volume of the oil-filled pore space, the interstitial water being treated as part of the rock system. For a given average permeability, the bulk volume can be either uniformly distributed as is porosity in a homogeneous sand or it can be lumped into a relatively few, large spaces as in a fractured or vugular formation.

What is particularly significant is that the transient response of the build-up curve will reflect only the movement of fluids into the interstices that are connected with the well drainage system. No other pore volume is of any commercial interest.

In a fractured pay with permeable matrix of given porosity, the proportion of the total effective oil in place that exists in the fractures can be calculated from the average porosity from build-up data simply by weighting the matrix and fracture porosities by the respective thicknesses.

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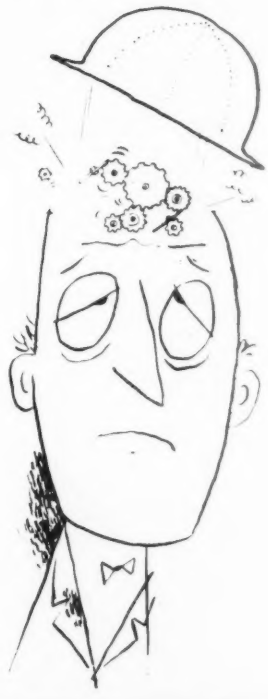

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Let

fracture porosity = 1.00
matrix porosity = f_m (given)
average porosity = f (from build-up)
fractional fracture thickness = x
fractional matrix thickness = 1.00 — x

By equating weighted porosities.

$$x = \frac{(f-f_m)}{(1.00-f_m)} \quad . \quad . \quad . \quad (5)$$

The fraction of total effective oil in place that is contained within the fracture volume is given by the expression, (X/f), or

$$\frac{(f-f_m)}{f(1.00-f_m)}$$

The product of (x/f) and oil in place from build-up analysis is a figure of merit to compare similar wells. It is the extent of the fracture system rather than the gross barrels in place that relates to the most economic recovery of oil under these conditions.

2. **Lenticular traps.** Knowledge of average porosity, which includes that which is away from the well bore, is of importance in areas where shale-outs or other facies changes occur rather abruptly. In these cases porosity determined from the build-up curve may differ markedly from that by analysis of cores from the well itself because of a deviation in the porosity distribution constant, d, from its normal value. In a permeability pinch-out type reservoir an edge well demonstrating an average porosity from build-up analysis considerably less than the known field average porosity would discourage future field development in that direction. Conversely, a higher than anticipated porosity indication suggests the improvement of sand conditions away from the tested well. When used in this manner, the well pressure performance becomes a new exploratory tool.

3. **Interstitial water determination.** One natural advantage in the development of build-up curve porosity relationships on the basis of oil-filled porosity is that such values can be compared with total effective porosity obtained by independent methods in order to calculate interstitial water. For example, if it be determined from the build-up test that 15 per cent porosity is effective and if log or other interpretations indicate 20 per cent total effective porosity, then the quotient 15/20 represents the well-known (1-connate water) factor. In this example 25 per cent water saturation is calculated. This method is essentially a different method and would therefore yield greatest accuracy in regions such as the Gulf Coast where high water saturations are frequently encountered and are often difficult to evaluate due to the thin or shaly character of the sand.

4. **Net thickness.** In the development of porosity correlations, net thickness is one of the basic elements that can never be factored away. However, if all other elements, including porosity, are known by other means, there is nothing to prevent a solution for net thickness. A determination of this type could have utility when the tested well had penetrated but had not been drilled through the pay zone.

5. **Permeability cut-off.** In certain oil fields such as the Rangely field, Colorado, where permeability is low and pay thickness is high, there is the problem of establishing which permeability groups actually contribute to production at any given time. Solution of this problem is important for it gives recognition to the fact that some fraction of total in-place oil is not subject to economic recovery. In this sense, recovery factor applies only to that portion of total oil saturation existing in the pore space characterized by a permeability equal to or greater than some specified cut-off value. It is within the power of the build-up curve to distinguish between active and inactive reservoir pore volume under given conditions of reservoir pressure and pressure drawdown. Fig. 4 and 5 suggest a procedure for establishing the effective cut-off permeability when detailed core analysis and interstitial water data are available.

Curve A, Fig. 4, is plotted to show results of core analysis. The more feet that are considered to be net, the lower becomes the average porosity of those feet. Curve B is plotted from a sequence of net thickness assumptions as applied to the build-up correlation curve. A well of a given performance and net thickness can have only one value for average porosity. A well of identical observed performance but with a different net thickness must have a different average porosity. Curve B is the result of assuming numerous net thick-

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ness values for the given performance data and plotting the porosity values that would exist under such conditions. The intersection of Curves A and B yields that one value of net thickness that satisfies both core analysis and pressure build-up relationships. Fig. 5 is plotted conventionally from detailed core data to indicate the number of feet characterized by a permeability equal to or greater than various specified values. When the number of feet, as determined from Fig. 4, is applied to Fig. 5, cut-off permeability can be read from the ordinate scale.

6. **Advance indication of water or gas breakthrough.** In general, the type of reservoir drive is immaterial to the interpretation of porosity from build-up curves. The well system responds only to the fact that an external pressure does exist and questions not from whence it came—so long as radial flow is applicable. If one periodically studies the performance of a well located near an expanding gas cap or near active edge water where channeling begins to take place, the well's observed pressure response no longer is the result of a radial compressive action on reservoir oil but rather is the result of highly compressible gas or negligibly compressible water encroaching linearly through a narrow sector. The proximity of this core to the well can completely mask the true porosity influence on the shape of the build-up curve. The writer has had the opportunity to observe this action in only two cases in separate fields; however, the advantages of an advance warning of channeling in the proper control of large gas cap and water drive reservoirs, particularly under unit operations, are apparent.

The Author

J. Randolph Buck is a consulting petroleum engineer in Dallas, Texas, specializing in oil and gas reserves and related work. Formerly he was associated with DeGolyer and MacNaughton as a reservoir engineer. His previous experience includes service in the field research laboratories of Magnolia Petroleum Company as a senior research engineer and in the petroleum engineering department of The Texas Company. He began his oil career with The Texas Company as a roustabout in South Louisiana following graduation from Worcester Polytechnic Institute, Worcester, Massachusetts, in 1938.

A registered professional engineer in Texas, he holds memberships in the Engineers Club of Dallas, the Petroleum Engineers Club of Dallas and other organizations.

Discussion

For the practical purpose of establishing that porosity does correlate with the reservoir fluid and rock properties when taken together with the significant build-up time, the writer has studied only the case of single phase flow of oil. Only wells that were near or above the bubble point pressure at the time of measurement have been considered. While a slight free gas saturation in the pore space does not appear to have a marked effect, a correlation developed on the basis of negligible gas saturation yields spurious results when applied to a well relatively late in the normal depletion process. Because the compressibility of gas so greatly exceeds that of reservoir oil, assumptions made with respect to saturation gradients away from the well bore become so poor that the prospects for valid porosity correlations under the simultaneous flow of oil and gas appear exceedingly dim.

On the other hand there is no appar-

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ent technical reason to prevent the development of quite excellent porosity-pressure build-up correlations for the case of single phase gas flow.

As in the interpretation of any other type of field or well data, the higher the quality of the data, the more significant will be the results. An understanding of basic principles aids in the procurement of good data. This point can best be made by citing the specific problem of properly running the P. I. and build-up tests.

Some operators have the well-completion practice of perforating, immediately thereafter running the potential and P. I. tests, then shutting the well in for the build-up measurements. This procedure is quick and convenient, but it many times ignores the theoretical requirement that dynamic equilibrium be reached in the drainage area prior to shut-in. Particularly in the less permeable formations, if the flow rate is not held constant a sufficient length of time, the transient pressure distribution does not equal the steady state distribution with the result that the build-up curve configuration will not reflect actual reservoir characteristics.

All mechanical systems exhibit inertia. The electrical equivalent of the well system shown in Fig. 1 and 3 does not. While electrical inductance conceivably could be added to the equivalent circuit to allow for inertia effects, it is rather pointless to complicate the analogy for the sole purpose of compensating for mal-practices in the taking of field measurements.

Summary

An oil well producing at or above the bubble point pressure can, upon shut-in, be treated mathematically as an electrical condenser receiving a charge through a series resistor from a direct voltage source. The object in making the analogy is to bring fluid mobility, pressure drawdown, and reservoir fill-up volume into a direct relationship with theoretically valid build-up time that can be readily calculated from actual shut-in time. The direct use of actual shut-in time in interpretative studies has heretofore been neglected. Through the use of time as factor, oil-filled porosity can be set equivalent to various expressions, the simplicity of which is determined by the number of justifiable assumptions chosen for convenience or practicality. Well data from several different fields representing a wide range of porosity values have been applied to such relationships to establish the practical importance and utility of the equivalent exponential curve concept.

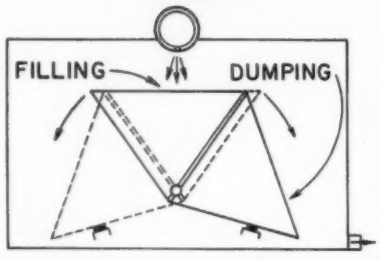
Porosity-pressure build-up correlations have a number of interesting usages beyond the more obvious bbl-per-acre determination for oil in place. Among these are:

1. Estimating connected fracture volume.
2. An exploratory tool indicative of sand conditions away from the well.
3. Determining interstitial water saturation.
4. Determining net pay thickness.
5. Determining permeability cut-off.
6. An advance indicator of gas or water channeling.

While some sort of universal correlation for the determination of in-place oil from build-up curves would, at first thought, seem to be a desirable objective, such a creation would be more deleterious than beneficial for the reason that judgment cannot be eliminated from interpretative work. No two workers will develop the same correlation from the same basic data, yet each when later applying his own curve to the same problem can arrive at the same answer.

Acknowledgment

The author wishes to thank John J. Arps, vice president, The British-American Oil Producing Company, for the kindness of his review and valuable criticism of the original manuscript. *



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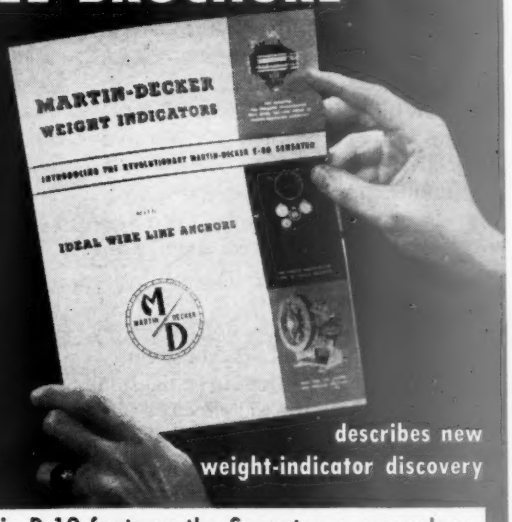

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Reduction of surface tension of injected water gives evidence of improving oil recovery in waterflood operations

SURFACTANT INFLUENCE ON FLOOD RECOVERY

Charles P. Milner[1] and Harry H. Power[2]

THE development of secondary recovery methods has focused attention upon the possibility of exercising some degree of control over the interfacial forces within an oil and gas reservoir by the injection of extraneous water containing surface active chemicals. The relationship between interfacial forces and oil recovery by waterflooding has been discussed previously. Although there is general agreement that a decrease in surface tension of the injection water should result in an increase in oil recovery, there is no general agreement that a satisfactory increase in oil recovery will be obtained from water-wet porous media, especially after the oil phase becomes discontinuous. The relationship between the rate of water injection and oil recovery has been discussed widely, but little information is available for the special cases where surface tension of the injected waters has been lowered by the addition of suitable surfactants.

The purpose of this investigation was: (1) To determine the effect of several surface active chemicals which were added to injection water on oil recovery from water-wet porous media: and (2) to determine the relationship between the rate of production and the oil recovery for each of the injection-water-chemical combinations used in this work.

The effect of surface tension on waterflood performance was determined by conducting waterfloods under reproducible conditions except for one variant—the surface tension of the injection water. The effect of production rate on oil recovery was investigated by conducting the series of experiments at two discharge rates, each of which was carefully controlled by 1/1000th of a cubic centimeter per minute.

Apparatus and Materials

Lucite tubes, nine feet long, with an internal diameter of two-inches and packed with unconsolidated Ottawa sand, served as the flow column for the experiments.

A highly refined oil with a viscosity of 9.8 centipoises and a specific gravity of 0.8153 at 96 F was used for the displaced phase. An 0.25 normal solution of sodium chloride and distilled water, with a viscosity of 1.007 centipoises and a specific gravity of 1.005 at 96 F was used as the displacing phase, both with and without the addition of chosen chemicals of given concentrations.

Table 1 lists the surface-active chemicals used in this work, their chemical names, formulae, molecular weights, solubilities in hydrocarbon and water and the relative order of adsorption on silica surfaces as determined in a separate set of experiments. The surface tensions at 96 F of the various flood waters are listed in Table 2.

A diagram of the flow system is shown in Fig. 1. The constant temperature air-bath maintained a temperature of 96 F and a mercury manostat pressure regulator maintained an injection pressure of 10 psia during each flood. The rate of production was controlled by a constant rate displacement pump which operated at a discharge

TABLE 1. Properties of Ethomids.

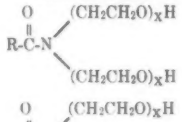
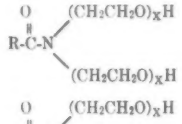
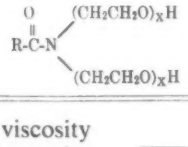
Trade name	Chemical name	Chemical formule	Molecular weight	Solubility: Hydrocarbons	Solubility: Water
Ethomid HT/60	N-substituted hydrogenated tallow amide (reacted with 50 moles of ethylene oxide)		2476	no	yes
Ethomid HT/15	N-substituted hydrogenated tallow amide (reacted with 5 moles of ethylene oxide)		496	slight	sparingly to 150 PPM
Ethomid C/15	N-substituted XXXX fatty acid amid (reacted with 5 moles of ethylene oxide)		660	no	sparingly to 175 PPM

TABLE 2.

Fluids used in the research work	Surface tension* dyneu per cm
50 PPM Ethomid HT/60 in brine (0.25 N NaCl)	47.0
50 PPM Ethormid C/15 in brine (0.25 N NaCl)	32.0
50 PPM Ethomid HT/15 in brine (0.25 N NaCl)	37.0
25 PPM Ethomid HT/60 and 25 PPM Ethomid C/15 in brine (0.25 N NaCl)	41.0
0.25 N sodium chloride brine	72.9
Oil	26.0

* These values of surface tension were measured at 96F with a Du Nomy Tensiometer. The surface tensions of the untreated brine and the various chemically treated brines were measured before their injection into the porous medium.

[1]Petroleum Engineer, Phillips Petroleum Company, Alvin, Texas.
[2]Professor of Petroleum Engineering, The University of Texas.

EXCLUSIVE

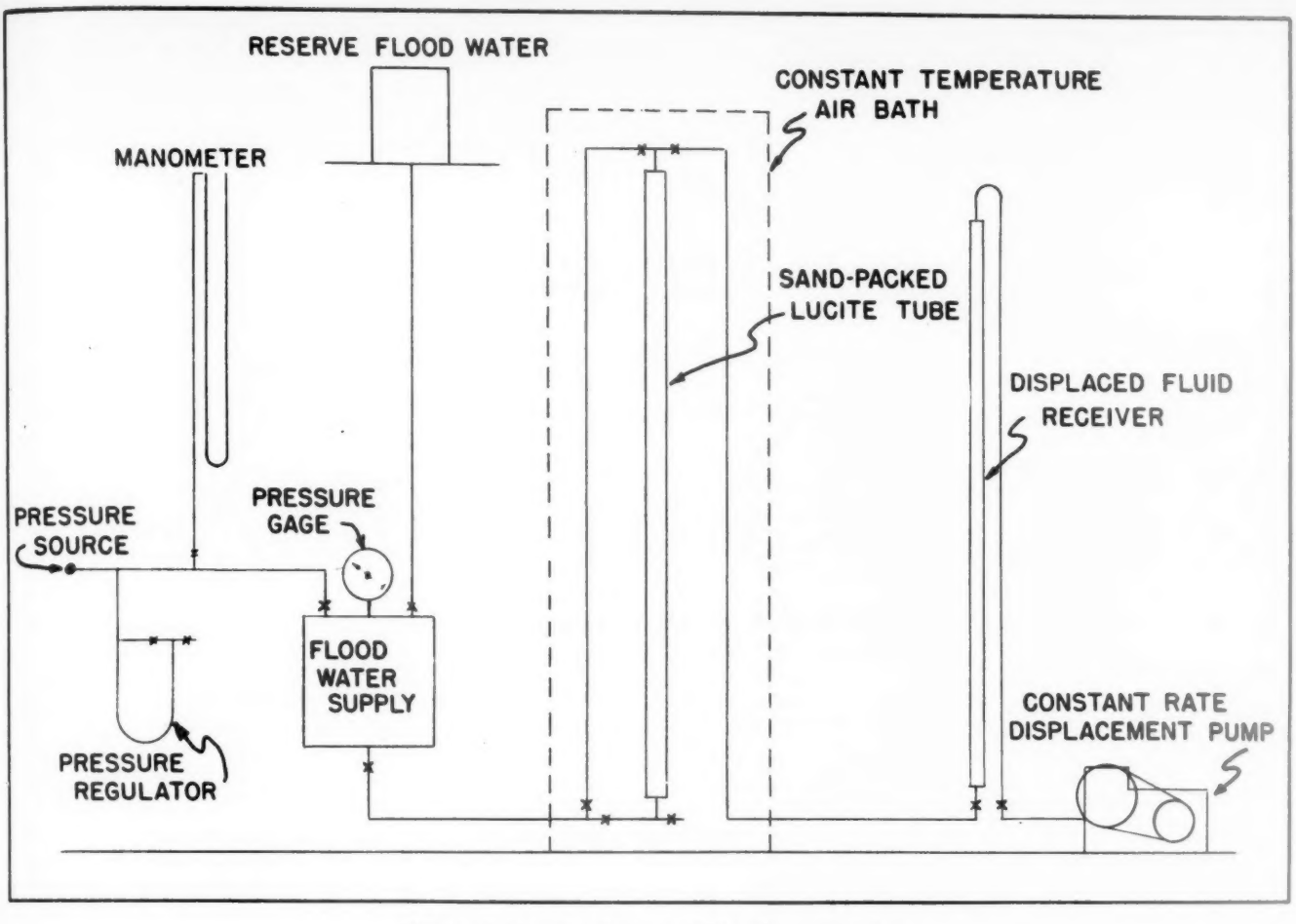


FIG. 1. Schematic diagram of flooding apparatus

rate of 0.297 cubic centimeters and 0.891 cubic centimeters per minute, respectively, for the two groups of flooding experiments.

The electrical circuit used is shown in Fig. 2. Electrodes were spaced at 2-in. intervals along the Lucite tubes and the circuit was so arranged that the voltage drop between any two electrodes could be determined easily. The resistivity of the sandpacked column and its contained fluids between any two electrodes was calculated from the measured voltage drops between the latter. The resistivity values were converted to brine saturations by means of a calibration curve which was verified by resistivity and overall material balance measurements on the flow column of interest.

TABLE 3. Summary of waterfloods.

Surface-active chemical	Ethomid HT/60		Ethomid HT/15		Ethomid C/15		Ethomid HT/60 and Ethomid C/15		Untreated brine		
Type	Non-ionic		Non-ionic		Non-ionic		Non-ionic		(Check run)		
Molecular weight	2476		496		660		—				
Solubility—Hydrocarbons	None		Slight		None		—				
Water	Soluble		Sparingly to 150 PPM		Sparingly to 175 PPM		—				
Concentration—PPM	50		50		50		50		0.25% Normal		
Surface tension—Injection fluid dynes per cm., 96 F	47.0		37.0		32.0		41.0		72.9		
Discharge rate—cc/min.	0.297	0.891	0.297	0.891	0.297	0.891	0.297	0.891	0.297	0.297	0.891
Connate water—% pore volume	18.15	18.36	19.31	17.43	16.38	19.50	17.60	17.77	20.10	19.96	17.66
Initial oil—% pore volume	81.95	81.60	80.70	82.40	83.60	80.55	82.50	82.10	79.90	80.00	82.30
Oil recovery											
Per cent pore volume	57.73	35.60	51.70	38.40	53.70	35.60	46.40	34.60	49.00	48.10	34.15
Per cent initial oil	70.50	43.60	64.10	46.50	64.25	44.22	56.30	42.10	61.30	60.10	41.50
Residual oil											
Per cent pore volume	24.20	46.10	29.10	44.20	30.00	44.95	36.00	47.70	30.90	32.05	48.15
Per cent initial oil	29.55	56.40	36.05	53.50	35.80	55.80	43.70	58.10	38.65	40.00	58.40
Water-oil ratio-cc/cc											
10 hr elapsed time	0.0322	1.503	0.0050	1.220	0.0062	1.042	0.0625	1.360	0.0125	0.0141	1.330
20 hr elapsed time	0.6050	1.980	0.3660	2.240	0.1265	2.790	0.7530	3.860	0.2680	0.4640	3.540
30 hr elapsed time	0.6010	*	0.4780	*	0.4130	*	0.7700	*	0.2710	0.5810	*
40 hr elapsed time	0.6230		1.0820		1.2500		0.8350		1.2000	1.2200	
50 hr elapsed time	0.8700		1.2660		2.2600		1.4160		2.7500	3.0000	
60 hr elapsed time	0.8950		3.0500		3.4100		3.2700		4.6500	3.7000	
	Discharge rate—0.297 cc per minute										
Cumulative oil production	cc	cc/hr	cc	cc/hr	cc	cc/hr	cc	cc/hr	cc	cc	Average cc per hr
10 hr elapsed time	149.0	14.9	161.0	16.1	161.0	16.1	136.0	13.6	153.0	163.0	15.8
20 hr elapsed time	259.0	12.9	285.0	14.3	312.7	15.7	235.2	11.8	290.9	285.7	14.1
30 hr elapsed time	368.6	12.3	400.0	13.3	429.5	14.3	331.8	11.1	427.1	396.4	13.7
40 hr elapsed time	470.2	11.8	483.2	12.1	507.0	12.8	423.3	10.6	500.3	475.3	12.1
50 hr elapsed time	560.8	11.3	560.8	11.2	561.0	11.2	495.6	9.9	539.7	519.4	10.6
60 hr elapsed time	653.0	10.9	604.5	10.1	601.4	10.0	537.3	9.0	575.9	562.7	9.5

* Because of high water oil ratios, experiment discontinued after 20 hours.

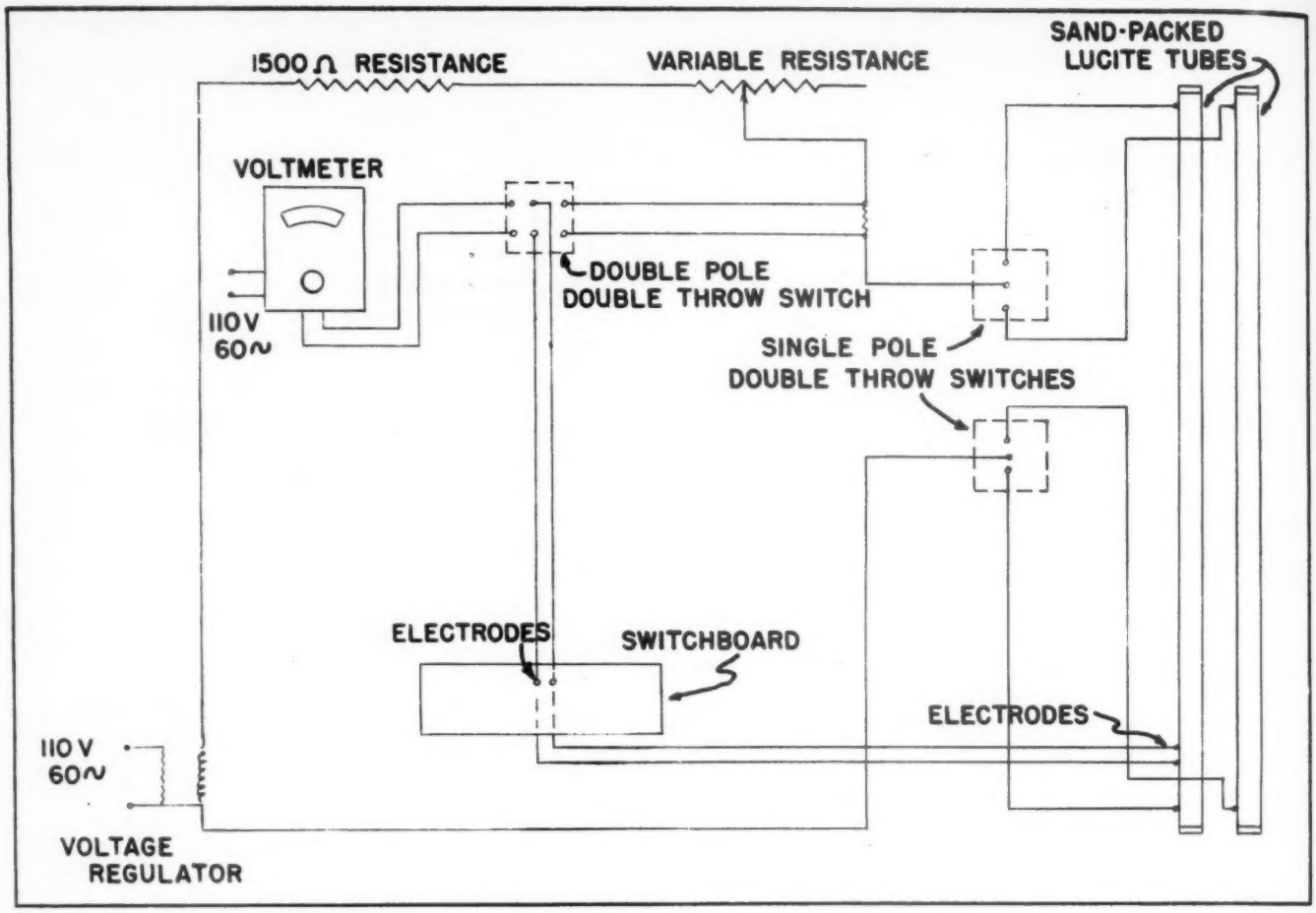


FIG. 2. Schematic diagram of electrical circuit

Procedure

The following procedure was employed for each of the waterfloods chosen in these experiments:

(1) A Lucite tube as described was packed with Ottawa sand in accordance with a predetermined procedure and placed in the flooding apparatus;

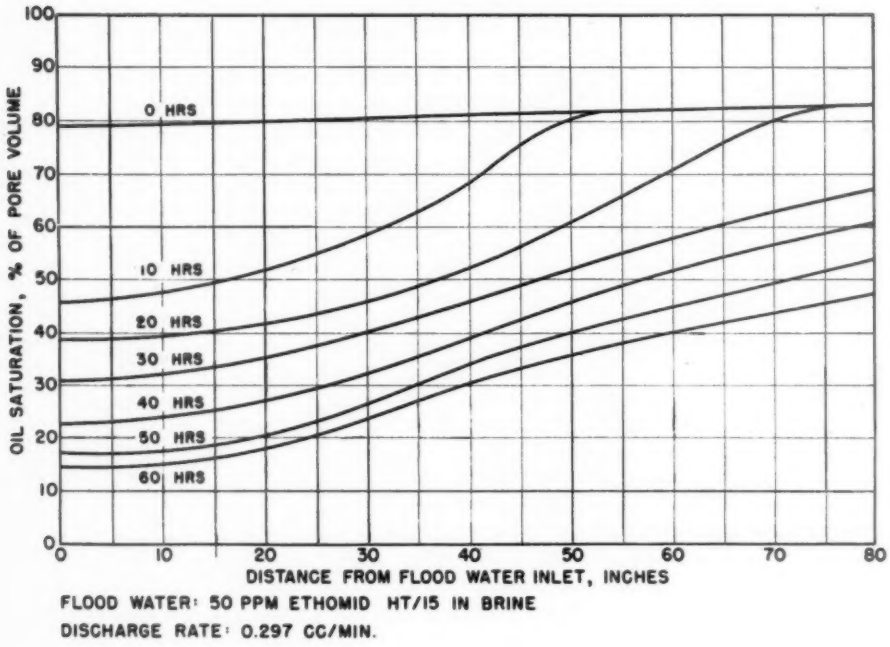
(2) The vertical sand-packed tube was saturated with 0.25 normal brine by flooding upwards;

(3) The brine-saturated column was then flooded downwards with oil until the flow of the latter was water-free;

(4) The saturation distribution of the brine was determined by the electrical resistivity method as described;

(5) The sand-packed column was then flooded at a constant production rate with one of the waters of interest until two pore volumes were injected. The entire saturation distribution from top to bottom of the column was determined electrically at periodic intervals during each individual flood.

FIG. 3



Experimental Results

Fig. 3 shows the oil saturation distributions at 10-hour intervals during one of the waterfloods conducted at a constant production rate of 0.297 cu cm per minute.

Table 3 summarizes the individual waterfloods according to type and concentration of surfactant used and shows by comparison the effect of increased production rate on residual oil saturation and, inversely, the effect of rate on recovery. Table 3 also summarizes the effect of chemical production rate and time on water-oil ratio; also the effect of chemical production rate and time on cumulative oil production.

Summary

The data of Table 3, with the exception of the flood using combined chemcals, indicate that the residual oil saturations as per cents of pore volume

and initial oil in place resulting from surfactant treated injection waters were lower than the residual saturations resulting from non-chemically treated brines. Conversely, the oil recoveries in per cent of pore volume and initial oil in place were higher for the chemically treated floods than for the non-chemically treated floods, with the exception of the experiment using two chemicals in combination.

Of the three successful chemically treated floods, the ones in which Ethomid HT/60 was employed were the most favorable with respect to residual oil saturation, oil recoveries, water-oil ratios, cumulative production and sustained oil production rates. The reasons for the superior performance of floods containing this surfactant may be ascribed to one or more of the following factors:

1. Ethomid HT/60 is comparatively soluble in water;

2. Auxiliary experiments with washed sand, non-washed sand and no sand show that surface-tension readings varied little for the chemically treated brine after an elapsed time of two weeks. Tests on other surfactants, however, after two weeks of elapsed time showed that the surface tensions were much higher, some even approaching those of non-chemically treated brine. Hence, the amount of adsorption of HT/60 on the sand surfaces was, comparatively, of a low order.

3. Auxiliary experiments employing a sand column and surface tension measurements of the chemically treated injection brine showed chemical losses in milligrams per square centimeter of sand surface per second for Ethomid HT/60 to be about one-third the value obtained for some of the surfactants exhibiting the greatest amount of adsorption on the sand surfaces.

4. In the preliminary adsorption tests performed independently by Kennedy and Guerrero, the sand adsorbed the chemical in the water with oil absent from the system in various proportions, but it was observed that some of the chemicals were adsorbed in a lesser degree at increased temperatures and pressures when an oil phase in addition to the water phase was present. In spite of the superior performance of HT/60 at pressures up to 1000 psi and temperatures up to 146 F, its use was considered to be prohibitive in view of its cost as compared to the value of the possible increase in oil recovery.

Additional investigations of the changes throughout the flow system in surface and interfacial tensions and contact angles; and the concentrations, adsorption, desorption and activities of surfactants dissolved in the floodwaters are indicated by the present work. A more thorough investigation of the adsorption-desorption dynamic process may lend more encouragement in the use of surface active chemicals in the economical recovery of disconnected oil droplets from water-wet porous media.

Acknowledgment

The authors acknowledge with thanks the financial assistance of the Orchem Corporation, Austin, Texas, through its fellowship which made this investigation possible. Acknowledgment is also made of the receipt of valuable guidance and criticism from Dr. Paul D. Torrey and Dr. Henry J. Prusick of the Orchem Corporation and from R. A. Morse of Stanolind Oil and Gas Company, Tulsa, Oklahoma. Appreciation is extended to W. E. Fickets who completed the drawings for the paper.

This paper is a condensation of a thesis prepared by the senior author for the master of science degree at The Unversity of Texas. Detailed information with respect to apparatus, procedure, data, conclusions, and bibliography may be found in this thesis which is a permanent record in the University of Texas library. * * *

Adomite

A New Product With Big Possibilities — Continental Oil Co. has developed a new material—Adomite—which can be mixed in crude oil to lower the fluid loss so that the oil can be used as a fracturing fluid. Field tests have shown excellent results and the product has been placed on the market. The Chemical Process Co. distributes Adomite as part of our fracturing services.

When applicable, the use of crude oil rather than refined oil for fracturing offers substantial operating economies in addition to many completion advantages. By simply lowering the fluid loss, Adomite allows usual amounts of sand to be carried in thin crude oil without screening out. Thus without excessive fluid loss, the oil will afford a more extensive fracture. Lower injection rates also are possible, less equipment is required, wells clean up better and faster, and the sale of the oil is not affected.

The chances are that Adomite has an immediate place in the completion work you have under way. If you will write to The Chemical Process Co. in Breckenridge, Texas, or contact one of our many stations in the Mid-Continent area, we'll be glad to tell you more about Adomite and give you descriptive literature without obligation.

THE CHEMICAL PROCESS CO.

SERVICING OIL & GAS WELLS

ACIDIZING FRACTURING

ADOMITE IS CONTINENTAL OIL COMPANY'S NEW ADDITIVE TO CONDITION CRUDE OIL TO USE AS A FRACTURING FLUID

Wild wells are the dilemma of all operators. These extremely costly accidents still happen, usually resulting in the total loss of a drilling rig, well bore, and valuable reservoir pressures. A typical case is presented above and at right which illustrates the accepted procedure for capping a wild well.

With most of the wreckage cle... away, a water-cooled container of ... plosive is spotted near the burning ...

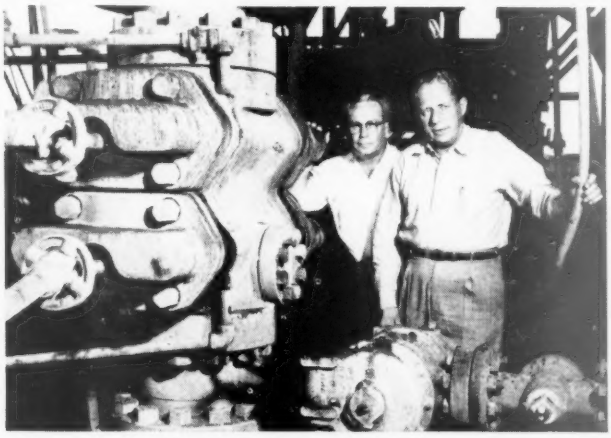
...From a rem... ...sion is set ...

IT DIDN'T HAPPEN HERE

"SS" SUCCESS STORY

The thousands of wells drilled each year that *don't blow out* seldom make the headlines. Two wells (right), drilled recently in the Gulf Coast area are typical. Both wells attempted to blow out but were quickly and easily shut in with the aid of Cameron's Type "SS" Pressure-Operated Blowout Preventers.

Cameron
IRON WORKS, INC.
P. O. Box 1212 - Houston, Texas
Export Office: 7912 Empire State Bldg., New York City

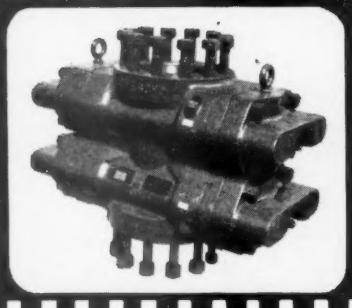


Cellar view on a Foster Drilling Company rig at Lake Arthur, Louisiana. Cameron's I. E. Moses and Foster's Toolpusher, Jack Beckham, pictured with the "SS" Preventer which closed against 6400 lbs. well pressure at the time well was attempting to blow out. "A mighty fine little preventer," Mr. Beckham stated.

S. N. "Scotty" Lamberth of Cameron, and Penrod Drilling Company's satisfied Toolpusher, Malvin Hennigan, with a Cameron "SS" Preventer in background. Under extreme pressure and difficult sanding conditions, the "SS" Preventer closed satisfactorily.

From a remote vantage point the explosion is set off, snuffing out the blaze.

With the fire out, the well continues to blow gas and oil until workmen install a Cameron Capping Manifold.



The Cameron "SS" Preventer at left was designed especially for drilling rigs having a low substructure. In addition to its numerous proven mechanical features which make all Cameron Drilling Control Units distinctive, its low over-all height and compactness make the "SS" particularly desirable where cellar space is limited.

XUM

EXPLORATION ACTIVITIES

OREGON

★ Oroco Oil and Gas Company and J. R. Simplot Company reported a gas blowout on their No. 1 Bolles well in Malheur County, Oregon, near the Idaho border. The well, drilled to a depth of 1540 ft, blew out 600 ft of high gas-cut mud before being brought under control. The wildcat is being drilled along the route of the proposed Pacific Northwest pipe line, and has attracted considerable attention. The well is about 25 miles northeast of a 7500 ft failure recently drilled by El Paso Natural Gas Company. It is 2 miles north of Oroco's 1 Carpenter, which is across the state line in Payette County, Idaho. The Idaho test was temporarily shut-in after finding gas shows at 1442 and 1750 ft. It was drilled to a total depth of 2775 ft.

★ Standard Oil Company of California has announced its intention to drill the first modern test for oil in Northwestern Oregon. Site of the exploratory well, Hoagland Unit No. 1, is about 10 miles southwest of Astoria, and about 70 miles northwest of Portland. Standard's Exploration Office said that the drilling of this wildcat well follows several years of geological survey in the area. It is part of the company's $200,000,000 program of exploration and development for oil and gas fields being carried out this year in many parts of the world, including the Pacific Northwest.

COLORADO

Great Basins Petroleum Company and SoRelle and SoRelle have reported that initial production tests on its discovery well in Weld County, Colorado, indicated an open-flow rate of 12,500,000 cu ft of gas daily from the J sand topped at 6680 ft.

NEVADA

★ Shell has completed Nevada's second producing oil well, Eagle Springs Unit 35-35, for an initial rate of 540 bbl daily of 28.9 gravity oil. It is located 1700 ft southwesterly from the discovery in the Railroad Valley area of Nye County. The confirmation well was drilled to 7500 ft, then plugged back to 6720 ft where it is producing from a gross interval between 6595-6720 ft. The discovery well is currently producing 200 bbl daily and has produced a total of 46,000 bbl since the date of its completion, June 12, 1954.

CALIFORNIA

★ Highland Oil Company is moving in to drill a test three-quarters of a mile west of Firebaugh in Fresno County. The test, Biancuchi No. 1, will be on the northeast quarter of Sec. 31, 12-14 and is scheduled to go to a depth of 5600 ft.

★ George J. Greer has completed Chimeneas-Arnold No. 28-24, a wildcat several miles northwest of the Taylor Canyon field in Cuyama Valley. Production is about 86 bbl daily cutting 50 per cent water. Greer is preparing to drill an offset, Greer-Trico-Burleigh No. 75-23, to further evaluate the area.

★ The Navy has opened a new exploratory campaign in Naval Petroleum Reserve No. 1 at Elk Hills in Kern County. The new wildcat is located about four and one-half miles east of the nearest of two Carneros zone wells already completed on the reserve, and about one mile northwest of two Stevens sand producers which penetrated the Carneros but did not test it. Standard Oil Compuany of California is the operator.

★ Reserve Oil and Gas Company has completed its first JV sand well in the Tejon Ranch field. The well, Reserve-E. W. Pauley No. 53-33 came in flowing at the rate of 598 bbl daily of high gravity, clean oil. Reserve is now going ahead with an active development campaign for the JV sand of Jewett age which was opened to production last December by Drilling and Production Company's JV No. 33-33.

★ Drilling and Production Company has moved in to drill a northwesterly offset to Reserve's new well, JV No. 42-33, which will also be a northeasterly offset to their own discovery well.

★ Richfield Oil Corporation is drilling below 8500 ft in its wildcat on Santa Cruz Island. Although no commercial showings have been reported, Richfield has staked location for a second test.

★ Pacific Western Oil Corporation has made a new gas pool discovery in the Belgian anticline area of Kern County with the completion of Anderson 63-A for 5,500,000 cu ft of gas daily through a 24-64-in. bean. The hole was drilled to a total depth of 6813 ft and is producing from the 3A sand in the Third Point of Rocks zone from an interval between 6255-6195 ft.

SUMMARY OF DRILLING ACTIVITY FOR MARCH
(As Compiled By Rinehart Oil News Staff)

States	New locations		Wildcat completions			Field completions			Junked & abnd.		Temp. abandoned		Abandoned locations		Current active wells	
	Wc	Field	Oil	Gas	Dry	Oil	Gas	Dry	Wc	Field	Wc	Field	Wc	Field	Wc	Field
Alabama	6	1	0	0	3	0	0	0	0	0	0	0	0	0	7	1
Arizona	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Arkansas	14	60	1	0	12	23	0	13	0	0	0	8	0	2	9	30
Canada (Williston B.)	13	52	4	0	19	48	0	6	0	0	1	0	0	3	11	22
Colorado	90	68	4	3	58	27	5	26	0	0	0	0	1	1	52	52
Florida	3	0	0	0	3	0	0	0	0	0	0	0	0	0	3	0
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Kansas	96	360	10	5	82	222	31	89	0	0	0	0	1	3	78	388
Louisiana	54	304	2	4	30	207	42	53	0	2	0	0	0	5	67	211
North	15	183	1	0	12	138	10	21	0	1	0	0	0	3	7	60
South	29	104	1	2	14	61	24	30	0	1	0	0	0	1	45	182
Offshore	10	17	0	2	4	8	8	2	0	0	0	0	0	1	15	29
Mississippi	15	25	0	0	14	17	2	10	1	0	0	0	0	0	13	28
Montana	7	7	0	0	6	9	0	5	0	1	0	0	2	2	18	23
East	4	4	0	0	0	6	0	0	0	1	0	0	0	0	7	12
West	3	3	0	0	6	3	0	5	0	0	0	0	2	2	11	11
North Dakota	4	8	0	0	3	18	0	1	0	0	0	1	0	0	6	19
Nebraska	28	39	6	0	19	20	0	17	0	0	0	0	1	2	15	40
Nevada	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
New Mexico	20	186	5	1	9	82	32	5	0	1	1	1	0	0	41	167
Eastern	14	128	5	0	6	82	1	5	0	1	1	1	0	0	31	122
San Juan	6	58	0	1	3	0	31	0	0	0	0	0	0	0	10	45
Oklahoma	77	827	10	6	53	476	17	174	0	0	0	5	6	28	60	524
South Dakota	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Texas	591	1557	45	21	349	958	86	218	3	7	14	11	6	50	428	897
East	35	44	1	3	39	20	8	18	0	0	0	0	3	8	21	65
Gulf Coast	38	144	3	7	29	72	10	30	1	2	0	0	0	3	32	97
North Texas	127	278	8	1	34	111	2	43	0	0	2	0	3	5	64	85
Panhandle	13	79	0	0	5	73	10	2	0	0	0	0	0	1	23	28*
South Texas	139	364	3	8	111	189	49	56	0	0	10	10	0	4	60	103
Border Co	40	94	1	0	22	62	0	5	0	0	0	0	0	1	32	70
West Central	110	136	17	1	58	89	2	42	0	0	0	0	0	0	54	39
West Texas	89	418	12	1	51	342	5	22	1	5	2	1	0	28	142	410
Utah	6	2	1	1	4	0	1	0	1	0	0	0	0	0	16	5
Wyoming	16	38	4	1	10	26	3	6	0	0	0	0	2	11	34	66
Totals: Jan	766	2636	108	31	673	1618	197	479	4	2	14	14	26	85	878	2316
Feb	798	2931	93	30	630	1745	144	548	4	7	17	22	34	126	877	2402
Mar	1040	3535	91	41	674	2133	219	623	4	11	16	26	19	107	863	2534
1955 Total	2604	9102	292	102	1977	5496	560	1650	12	20	47	62	79	318	—	—

* Figure incomplete.

WYOMING

★ Westates Petroleum Corporation announced the completion of its Skelton B2-7 well, at Hamilton Dome, Wyoming, as a Curtis sand producer at the rate of 180 bbl daily of 20 gravity clean oil.

★ Husky Oil Company has completed its No. 1 Webb in Gaines County as a producer in the Devonian. The wildcat was drilled jointly by Anderson-Prichard Oil Company, U. S. Smelting Company, and Husky Oil Company. On state potential tests the No. 1 Webb produced a total of 607.51 bbl of 36.5 deg oil on natural flow in 24 hours through a 30/64-in. choke. Pay formation was topped at 13,024 ft. The well was drilled to a total depth of 13,133 ft and at that point was still in oil saturated Devonian and no water had been encountered. A total of 13,129 ft of 5½-in. casing was run and cemented. The casing was perforated from 13,028 ft to 13,060 ft and from 13,112 ft to 13,128 ft.

TEXAS

★ A new pay for the Payton field of Ward County was reported by Cities Service in the dual completion of its Brandenburg "B" No. 1 for a calculated open flow of 62,000,000 cu ft of gas daily from the new Ellenburger pay and 12,500,000 cu ft from the Devonian. The new Ellenburger production is from open hole between 10,086 and 10,215 ft. Almost 46 bbl of 64 deg condensate is being produced with each million cubic feet of gas. Nearest Ellenburger production is in the Santa Rosa field, three miles from the Payton field Ellenburger discovery, and is 27 miles north of Fort Stockton. Production from the Devonian formation is from perforations between 6662-6712 ft, 6744-6794 and 6825-6870 ft. Approximately 60 bbl of 43 deg condensate is being produced with each million cubic feet of gas from the Devonian.

MISSISSIPPI

★ Twenty-one of the 25 wildcats and semi-wildcats underway in the state are drilling below 10,000 ft. The S. W. Richardson No. 1 Walker, in the Gwinville area of Jefferson Davis County was last reported fishing at 18,268 ft.

★ Sun Oil's No. 1 Southern Package Company was drilling on junk lost in hole at 14,268 ft. Total depth of the well, in Copiah County, was 15,207 ft.

★ Several of the wells were last reported coring. Among them are Skelly's No. 1 Gambrekem, Jones County, at a depth of 12,025 ft; Union Producing Company's No. 1 Knight at 12,223 ft, and No. 1-D Ruffin at 12,200 ft, both in Jasper County.

who is this guy?

This is the man who makes the fabulous Southwestern petroleum industry tick! Whether he's doing a rough and rugged job in the field . . or whether he has come up through the ranks to the presidency of his company . . he's a sort of composite spirit of the men who drill for and produce oil and gas.

Joe Roughneck is the No. 1 boy in the great Mid-Continent region where 75 per cent of the nation's crude oil is produced. To help him do a better job, Lone Star's completely integrated steel mill was built right in the middle of Joe's workshop, and today, Lone Star is turning out API casing, tubing and line pipe for his special convenience in getting the job done!

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To obtain more information on products advertised see Page E-41

What's doing in DRILLING

★ Offshore drilling this month has been most active, with several new drilling barges commissioned.

★ Ocean Drilling and Exploration Company, operating out of New Orleans, Louisiana, has put into service the "John Hayward," a barge designed for 30 ft waters, under contract for Shell.

★ The Offshore Company, Baton Rouge, has commissioned a new 6100-ton-barge, appropriately named "Offshore Company No. 2." The barge has been put to work drilling a well for Humble near Grand Isle.

★ The CATC group (Conoco, Atlantic, Tide Water Associated, and Cities Service) has constructed a new $1,500,000 drilling platform in the deepest water yet—97 ft, on Grand Isle Block 47. The unit has a helicopter deck, as well as air conditioned quarters for 30 men. Nine wells can be drilled from the one location without moving the platform.

★ American Tidelands, Inc., recently launched a submersible drilling barge for use in Louisiana waters. The newly organized company is headed by President T. L. Jordan, independent oil operator and large boat and barge operator on the Mississippi, and Vice President Spencer Rowan, former assistant drilling and production superintendent for The Texas Company in the Gulf area.

★ Offshore drilling in California received a shot in the arm recently with a court ruling permitting drilling from artificial islands. New rulings will have to be put into writing, however, before permission is granted to drill from offshore platforms or drilling barges.

★ Stormy seas were also playing havoc with the drilling barges. In one instance, a barge being moved into Texas coastal waters was damaged and several crewmen hurt.

★ Weather also gave drillers in the Texas, Oklahoma, and New Mexico areas some hard times, to an extent that general activity was literally stifled. In the Permian Basin, sand storms that have swept the Southwest halted operations for several days.

★ High winds toppled derricks near Abilene, Wichita Falls, and Sherman, Texas. One man was killed, and seven rigs were down in the Sherman-Denison area.

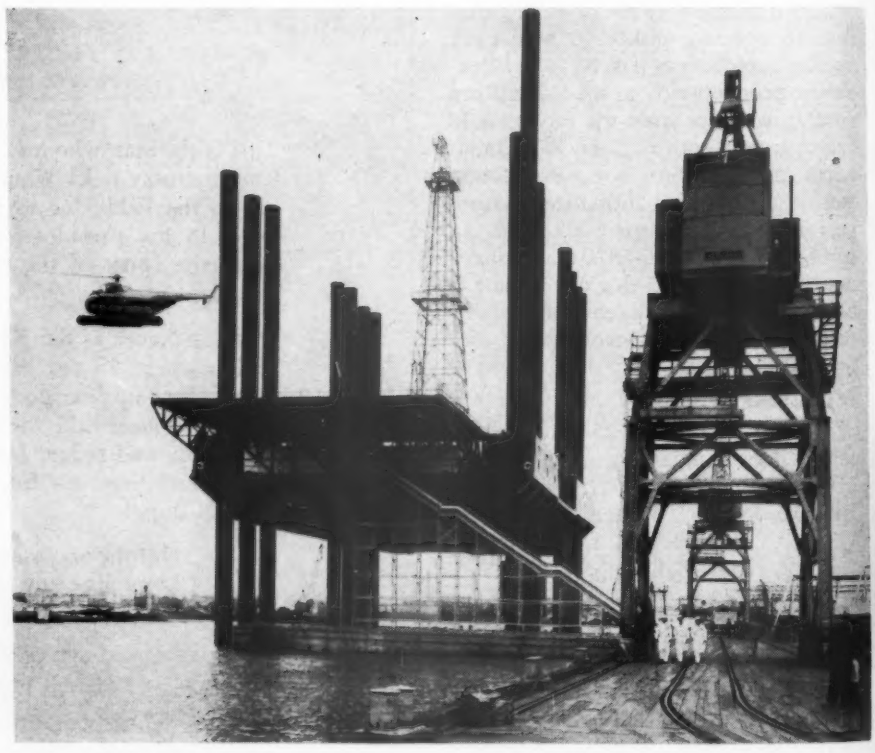
★ In the Sholem Alechem field of Oklahoma, lightning struck a couple of oil-filled tanks belonging to Earl Rader in another weather freak. Rader is a contractor operating out of Ardmore.

★ All the news isn't bad this month. Word has come from reputable authorities in Canada that the footage price of drilling in many areas would soon increase to "economic" levels. Contract drilling in Canada has come of age and is stabilizing itself, operators report.

★ Opinion expressed by several oil companies would suggest lower prices, as drilling time is shortened and drilling contractors seem to have mastered costly lost circulation and fishing troubles. Others admit that never before have producers been delivered cleaner, more accurately drilled holes, in as short a time, and for as low a price, as is the case today.

★ Oil emulsion muds have gone far in providing clean hole, just as jet drilling and air and gas drilling have chopped the drilling time tremendously. The time expended by producers in cleaning up a hole after the large rig is moved away—and that time consumed by a company representative on location as drilling progresses—is no small item in anyone's expense book.

★ These oil companies may expect well contracts completed even sooner as a result of air drilling tests conducted and made public late in April through the joint efforts of Reed Drilling Company, Inc., Keener Oil Company, and Clarence L. Boyd, Inc., all of Tulsa, Oklahoma. Experiment conducted in drilling a well near that city showed that a well could be successfully completed—from drilling the rathole to diamond coring the sand—in a minimum amount of time at increased savings. Statistics on this well will be presented soon.



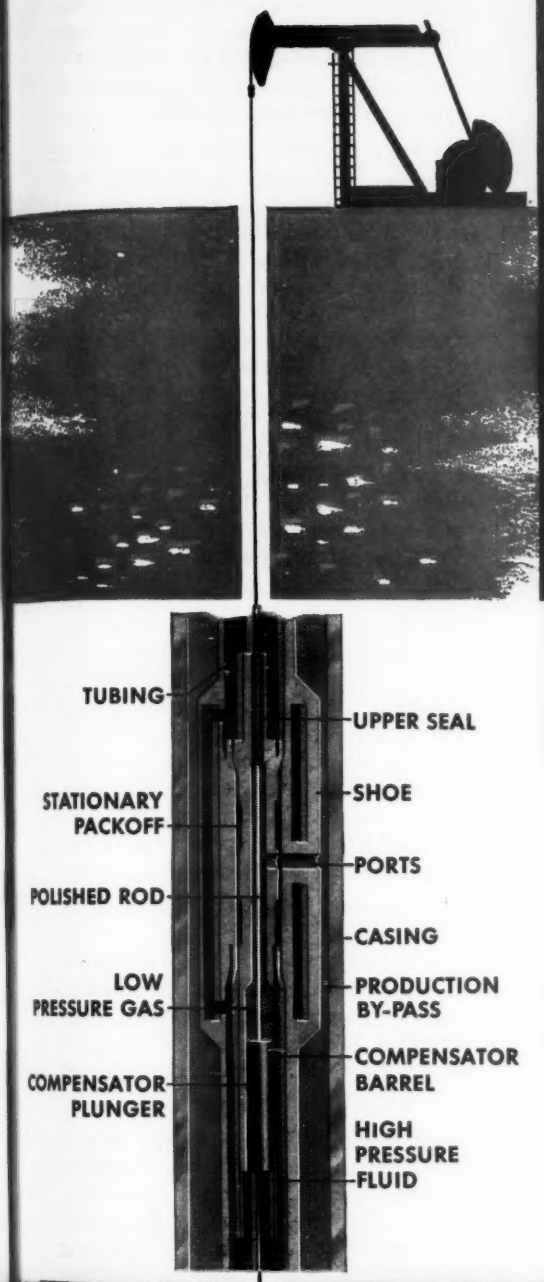
Hundreds of well-wishers gathered recently at Orange, Texas to participate in the christening of "The Offshore Company No. 2," one of several recent deep-water rigs to be put into service. Complete even to the helicopter landing port, the new four million dollar rig boasts the most modern facilities and drilling equipment. Unit was built for Offshore by Consolidated Western Steel division of U. S. Steel Corporation.

SOMETHING FOR NOTHING

sounds mighty appealing, but like "lifting yourself by your bootstraps," it is in violation of the basic laws of science. Therefore, when we first told oil men how much weight reduction could be expected from a Rod Weight Compensator, they were skeptical and started calling the Compensator "Operation Bootstrap." That was when "Bootstrap Joe" came into being and we like to think of him as symbolic of the mighty upward thrust delivered midway down the rod string by the application of the hydrostatic pressure on the Compensator plunger.

But now the story has changed. Operators have witnessed installation after installation where the dead weight of the sucker rod string has been reduced by 33%. Now they are telling us it isn't "Operation Bootstrap" at all — that a Compensator is actually a two stage counterbalance with part of the rod load balanced out half way down the well. Others tell us we have placed an upside down pump in the middle of the rod string, and the lower pump only moves the fluid to the Compensator on the upstroke, while the Compensator boosts it to the surface on the downstroke.

We still like to believe in "Bootstrap Joe," but we don't argue. We do know that an Oilmaster Rod Weight Compensator permits more oil to be produced from greater depths than any other known means of sucker rod pumping. If deep well pumping is your problem, we suggest you get in touch with your Oilmaster Representative for further details on the...



oilmaster PUMPS FOREMOST IN THE INDUSTRY

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ROD WEIGHT COMPENSATOR

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XUM

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Mar. 21	Mar. 28	Apr. 4	Apr. 11
Pacific Coast	158	160	157	154
Oklahoma	316	281	342	323
Kansas	187	191	186	191
Rocky Mountains	196	212	213	213
Canada	196	201	157	148
Ark-La-Tex	177	169	171	173
West Texas and New Mexico	524	506	510	511
Gulf Coast	581	563	566	581
Illinois	127	109	103	131
North Texas	336	340	346	361
Total	2798	2732	2751	2786

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company

KIMRAY INC.

1" High Pressure Motor Valve

RUGGED—
4000 lb. W. P.

COMPACT—
9¼" x 12½"
Weight: 25 lbs.

ECONOMICAL—
$105.00 Complete

• Screwed ends: angle or thru body
• Reversible: pressure opening or pressure closing
• Patented Teflon packing: no adjustment
• Inner valve characterized for throttling service—gas or liquid
• Standard trim is carbide plug and hardened chrome alloy seat; sizes: ⅛" - 3/16" - ¼" - ⅜" - ½"

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TEX.—Abilene: Control Equipment, Inc.
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LA.—Lafayette: Clif Mock Co.
LA.—Lake Charles: Clif Mock Co.
LA.—New Iberia: Clif Mock Co.
LA.—Shreveport: Maria Tool Corp.
NEW MEX.—Farmington: Oil & Gas Equipment Corp.
SOUTH AMERICA—A-Z Export S. A., Maracaibo—Puerto la Cruz—Bellaire, Texas

★ About the time we think we have the rotary drilling business down pat, Gustav Egloff, one of oil's foremost chemists, tells us we will be melting down tomorrow's wells with atomic energy. Not only did the man say that wells would be completed more quickly and at very little cost, but that a highway tunnel through the Continental Divide could be bored in a matter of weeks by these same methods.

★ There are a few people in this world, though, that aren't as familiar with twentieth-century oil field words and ways. This is a lesson that must be relearned every time a rank wildcat is drilled in some really new area. When the E. L. Oliver Drilling Company of Oklahoma City, brought the first rig to the island of Jamacia recently, the local newspaper carried the story under the banner headline "DRILLING FOR OIL BEGINS." Oliver is under contract to Base Metals, Ltd., who has exclusive rights on the island. Several other American companies are doing some horse-trading for offshore leases.

★ A fairly new area for oil men, Paradox Basin in southeastern Utah, has captured attention in the Rockies. Last year was spent buying up leases by individuals and small independents; now the drilling companies are moving in in large numbers. Active last month in Grand County were companies operating for MacMillan, International, Kimball, Delhi, Modco, Carter, Canab, and Toles.

★ Colorado Oil and Gas Corporation will be doing a lot of drilling in the Rockies this year, company officials say. A good portion of its 100-well drilling program will be in this area. Colorado also will sink several on holdings in the Mid-Continent, Canada, and Gulf Coast.

★ Sunray has been keeping several drilling contractors busy, with 32 active field operations going on in May. One of the nicest wells brought in by that company was the Father Flanagan Boys Home No. 2 well in Stafford County, Kansas. A potential of 1056 bbl per day was registered from a production depth of 3615 ft.

★ To try something different, or if there just isn't a contract to be had, you might try what L. B. Conner of Denver, Colorado, is doing. Connor will be core drilling for uranium in Utah this month.

★ Although a rig operator may love to tell about completing a long string of producing wells, or such, there are very few—regardless of the size of the organization—that won't shout just a little louder and longer about a shiny new rig. We've been told that Harms-

Southeastern Drilling Company, Dallas, Texas, earned on award by the Texas Safety Association for 426,567 accident-free man hours of operations on both land and submersible barge rigs recently. Among those present at the time of the award were Thurmond Green, Sun Pipe Line; W. E. Armentrout and William P. Clements, Jr., Southeastern Drilling; E. C. McFadden, Texas Employers' Insurance Association, president of TSA; Ross Carr, Gulf; and W. I. Kent, Magnolia.

Burt Drilling Company, which operates out of Wichita, Kansas, has two new Emscos, a 250 and a 350. They are making hole in the Great Bend and Wichita area for Kansas Exploration and C. C. Oil Company.

★ Wildcatting for the S. O. Company in the Lerdo area of California is a new National rig No. 3-50 owned by Newton Drilling Company of Coalinga.

★ Dellson Drilling Company, Denver, Colorado, who has been keeping busy in the South Glenrock and Fiddler Creek fields of Wyoming, has a new GB 500. The company's new Rig No. 3 is under contract for 6200 ft Fiddler Creek well by Sioux Oil Company near Newcastle.

★ Although a lot of time is spent searching for the outstanding and the unusual, one item must be mentioned that is getting to be regular practice with most contractors—and is paying off handsomely. That's safety. The weekly safety meeting is accepted on every progressive rig from Alice, Texas, to Albion, Illinois.

★ Noah Petroleum Company, drilling for itself in Hamilton County, Illinois, has two years without a lost time accident, to show for its safety practices.

★ Unit Drilling Company, Bristow, Oklahoma, has drilled 400,000 ft of hole with only four fishing jobs, and boasts a two-year safety award last year for Rig No. 1. Rig No. 2 was presented with a two-year no loss of time award this year.

★ Carter Drilling Company's little units are making some records, too. Rig No. 1 has run 789 days without a lost time accident; Rig No. 2 has completed 828 no-accident days. Rig No. 3 broke a 792-day streak last week, when a member of the crew received a hand injury.

★ Miller Brothers and Bowling, of Alice, Texas, has its three rigs on the safety bandwagon now. Ocean Drilling and Exploration Company, of New Orleans, Louisiana, is to commended for the completion of a Bureau of Mines first aid training course.

Bowen Releasing Spears not only insure the ability to pull the fish but also permit *release* at will. In the releasing position, there is no possible means of forcing the slips outward. The slips are in a neutral slot which insures that they cannot be expanded to contact the fish.

For your inside-the-pipe jobs and for holding liners and casing while landing, this efficient spear—with only six simple parts—gives a positive internal grip on the pipe. Easily withstands hours of steady jarring, yet release has never been known to fail because of its *perfect releasing* mechanism.

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Write for a free copy of Bowen's Operation and Instruction Manual which tells of the greater service and satisfaction to be obtained from BOWEN RELEASING SPEARS.

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RUNNING TOUR with MEN in the INDUSTRY

▸ Six employees of Stanolind Oil and Gas Company's North Texas-New Mexico division, with headquarters in Fort Worth, Texas, have received diamond 30-year service pins. They are **John R. Evans,** vice president and division manager; **Elmer S. Pester,** assistant division accountant in Fort Worth; **Charles V. Campbell,** Greggton, Texas, field superintendent: **William P. Collis,** head roustabout at Iraan, Texas; **Altus V. Maxwell,** process foreman, South Fullerton gasoline plant, Andrews, Texas; and **William O. Grace,** resident pumper at Panhandle, Texas.

Seven locations within the division received awards for safety records completed during 1954. The division as a whole, the division office at Fort Worth, and the Hobbs, New Mexico, producing area, were cited for completing over a million man-hours of work without a lost-time injury. Field seismograph parties 6, 10, 12, and 22 were cited for completing 5 years or more of field operations without a lost-time injury.

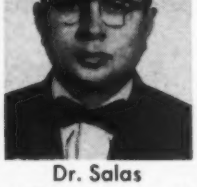
Veterans of 30 years' service with Stanolind Oil and Gas Company are Elmer S. Pester, assistant division accountant, Fort Worth, Texas; Altus V. Maxwell, process foreman, Andrews, Texas; William P. Collis, head roustabout, Iraan, Texas; and Charles V. Campbell, resident pumper, Pampa, Texas. They are among seven employees in Stanolind's North Texas-New Mexico division awarded 30-year service pins at the division's annual award dinner in Fort Worth.

▸ **Frank S. Carter** is now associated with **J. D. Wrather, Jr.,** Dallas, Texas, as production superintendent. Carter had been with the Texas-Pacific Coal & Oil Company as assistant manager of production at Fort Worth.

▸ **Robert I. Dickey** has joined Texas Pacific Coal & Oil Company's exploration department in an executive capacity. He recently resigned as vice president of Forest Oil Corporation, Midland, Texas, where he had directed West Texas and New Mexico operations since 1952.

▸ **George H. Ketchum** has been appointed assistant to the manager of the land department of General Petroleum Corporation. Ketchum, in this newly created position, will be responsible for administration of operating agreements and related land acquisitions.

▸ **Dr. Guillermo Jose Salas,** petroleum engineer with Compañía Shell de Venezuela, Ltd., has been transferred from La Concepcion field in Maracaibo district, to Lagunillas, Bolivar district, as a field exploitation engineer in the area off-shore Maracaibo Lake. He studied at Universidad Nacional del Zulia in Maracaibo and at the University of Tulsa, Tulsa, Oklahoma, where he obtained his degree in petroleum engineering.



Dr. Salas

▸ Awards for "distinguished and meritorious" service to the American Petroleum Institute Mid-Continent district were presented to **H. O. Harder,** Sunray Oil Corporation; **H. S. Kelly,** Phillips Petroleum Company; **F. M. Anderson,** Halliburton Oil Well Cementing Company; **Frank Willibrand,** Sohio Petroleum Company, and **G. C. MacDonald,** Gulf Oil Corporation at a district meeting in Amarillo, Texas, by **A. W. Thompson,** API vice president of production.

▸ **Hugh H. Beach** was promoted to chief geologist, The Texas Company's producing department, and transferred from Calgary to Houston, Texas. Beach succeeded **G. M. Clement,** who was transferred to the company's research division at Bellaire.

T. L. Kunkel has been named assistant division manager of the geophysical division of the producing department.

▸ Humble Oil & Refining Company has announced changes in its production department supervisory personnel. **E. E. Marshall,** formerly district superintendent at Livingston, Gulf Coast division, transferred to the Mallalieu district, Louisiana division, as district superintendent. **James C. Posgate,** division petroleum engineer, Louisiana division, was promoted to assistant division superintendent of Louisiana. He was replaced by **Harry Pistole,** formerly division petroleum engineer of the East Texas division. **John G. Calvert,** assistant division petroleum engineer of the East Texas division, was promoted to division petroleum engineer there.

W. J. Greenwald, assistant chief reservoir engineer, petroleum engineering division, Houston office, transferred to the East Texas division as assistant division petroleum engineer. Greenwald was replaced in Houston by **H. B. Barton,** formerly assistant area petroleum engineer, California area. Succeeding Barton in California is **C. M. Carothers,** district petroleum engineer, Stratton district, Southwest Texas division.

R. B. Riggs, Jr., district petroleum engineer, Gladewater district, was transferred to the petroleum engineering division, Houston office, as senior petroleum engineer.

R. R. Die, senior petroleum engineer, Southwest Texas division office, moved to the Scott & Hopper district, Southwest Texas division, replacing **J. E. Willingham,** who transferred to division office as senior petroleum engineer.

George B. Wells, district chief clerk, Government Wells district, Southwest Texas division, was transferred to the Wasson district, West Texas division as district chief clerk.

W. T. Slick, Jr., senior petroleum engineer, petroleum engineering division, Houston office, transferred to the Winters district, North Texas division as district petroleum engineer. **H. A. Stanford,** roustabout gangpusher, Avoca district, North Texas division, was promoted to farm boss at the Pampa district, North Texas.

▸ **Barron Housel** has been named assistant to **J. W. McColl,** superintendent of Cities Service Oil Company's land-lease division. **Mark F. Payton** was transferred to Bartlesville, Oklahoma, to fill Housel's former position as division landman.

▸ **Stanley Harlow** has been appointed vice president in charge of drilling and production for Harlow Petroleum Company, Tulsa, Oklahoma.

▸ **Dr. Frank Press** has been appointed professor of geophysics in the division of the geological sciences at the California Institute of Technology.

▸ **E. W. Endter** recently resigned as president of the California Oil Company, a Standard Oil Company of California subsidiary. The resignation followed an announcement by **Louis E. Wolfson** that Endter was a candidate for a directorship of Montgomery Ward & Company on the Wolfson slate. **E. W. Pickard** was appointed president of California Oil Company to succeed Endter.

▸ Officers for 1955 of the Mid-Continent section, American Institute of Mining, Metallurgical and Petroleum Engineers, are **Russell H. Gwinner,** First National Bank and Trust Company, Tulsa, chairman; **Guy F. Williams,** Dowell Incorporated, Tulsa, first vice chairman; **Don R. Johnson,** Gulf Oil Corporation, Tulsa, second vice chairman, and **Michael J. Rzasa,** Cities Service Research & Development Company, Tulsa, secretary-treasurer.

▸ **W. S. Crake,** formerly chief mechanical engineer for Shell Oil Company's Houston, Texas, area, has been advanced to area production superintendent.

Succeeding Crake is **J. R. McEntee,** who has been serving as chief development engineer on the staff of the technical services division.

Shale Oil by Self-Distillation. "Controlled underground combustion" is the principle on which Sinclair is depending to permit recovery of shale oil from its natural habitat according to recent announcement by Sinclair Research president W. M. Flowers. A setup is to be made near Rifle, Colorado, where some of the richest oil shale deposits occur, to carry out experimental work to determine optimum operating conditions; operating techniques, and cost figures on the process. No details of the procedure have been released by Sinclair Research. Of course the major and potentially huge, advantage over other processes is that mining need not be done. This avoids the great expense of taking and handling the shale, the large proportion of which is entirely inert and must be rejected after passing through the kiln that drives off the shale oil. The idea in this process is to liquefy the oil in place and enable it to be pumped to the surface as is crude oil in the conventional well.

★ ★ ★

New Houdresid Cat Cracking Process. Following a year of operation of a catalytic cracking process for cracking heavy residual fractions direct, Houdry Process Corporation announces its Houdresid Process for license to the industry. The outstanding feature of this process is that the residual metals found in practically all reduced crudes do not "poison" the catalyst used in this process, a matter which has been a deterrent to direct cat cracking of residual oils heretofore. Operating on a bottoms mixture of Texas, Louisiana, and Mid-Continent crudes as charge stock, Sun Oil has obtained about 64 per cent gasoline. This compares very favorably with 52.5 per cent gasoline from the same residual by vacuum distillation plus cat cracking of the vacuum overhead. The unit's design is based on the Houdriflow moving-bed cat cracking equipment.

★ ★ ★

New Iso-Plus Reforming Process. By a variety of "routes" which involve Houdriforming along with other processes, this new system for producing 100-octane number gasoline has been developed to the commercial stage and is reported to permit conversion of low-grade naphthas high in paraffins wholly to 100 octane rating products in high yields. Operating on naphtha having 46 per cent paraffins, and following three different routines, the process has yielded, 86, 87, and 91 per cent of 100 octane number gasoline. These routines involve various combinations of Houdriforming with depentanizing, aromatics extraction, recycle of low octane number (paraffinic) raffinate, butane blending, catalytic polymerization, depropanizing, etc. The Sun Oil Arosorb process was employed to separate aromatics and thus obtain the recycle fraction, but any efficient solvent extraction process may be employed, it is announced.

★ ★ ★

RF in Distillation. Radio frequency oscillometry permits the operator to determine instantly the composition of a liquid stream, that is, one that is nonconducting, while the operation goes blithely on without any interference whatever from the determination. By this method it can be determined when a column is in equilibrium, when to "cut" fractions more precisely, and the optimum reflux ratio to use — all to much greater efficiency than by temperature readings. All this is accomplished via a new still head; this head enables the operator to determine continuously the capacitance of a special condenser, made up of a pair of metal cylinders that cover a tube through which the condensate (distillate) flows. This was announced by L. H. Wilson of New York University, before a meeting of the American Chemical Society Metropolitan section.

★ ★ ★

$865,000 for Basic Chemical Research. Three colleges in Texas — Rice Institute, Texas A&M, and Texas University, have been awarded this sum, in total, from the Robert A. Welch Foundation, formed from the will of the oil-sulfur magnate of that name, who died two years ago in Houston. The grants cover a three-year period. The Foundation has $21,000,000 to spend for research, largely basic, fundamental research in chemistry, and all to be spent for projects in Texas. The stipend to Rice totals $295,422; to Texas A and M, $275,000, and to Texas U, $294,600. The fields to which these sums are to be applied include a wide variety of subjects in both organic and inorganic chemistry.

Tar Sands to "Give." The most promising prospects yet seen for the economical commercial production of oil from the stupendous quantities of tar sands in Canada's Alberta province is that of the Can-Amera Company, using a process developed by G. R. C. Coulson of Calgary, Alberta. Principles of the process include adding a light solvent oil to the tar and applying pressure, and centrifugal force to separate the tar-oil-solvent liquid from the inert solid sand in which the oil was deposited by nature.

Plans now are for Can-Amera to build a $35-$50 million dollar plant at the site of the sands to be leached. This plant will include mining apparatus and installations, the oil-sand separation system and finally a pipe line, reportedly 10-in. or so, to Edmonton, Alberta, where the recovered oil will join that in the Trans-Canadian line en route to Duluth.

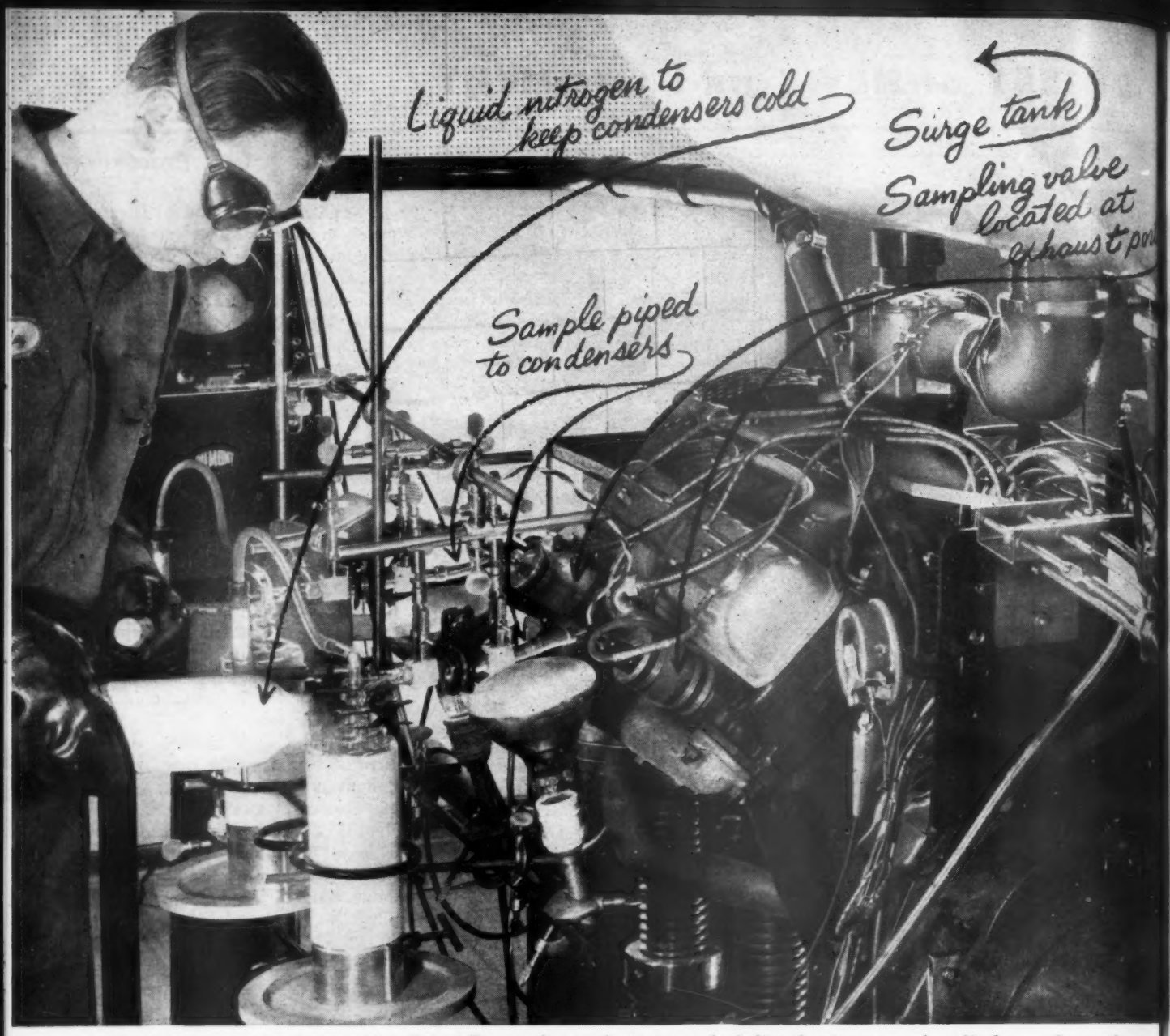
Pilot plant work included the shipment of 20 tons of the raw tar sand to Poughkeepsie, New York, to a unit there to carry out the process. This plant later was transferred to Northern Alberta (Bitumount) and is again operating. If this large-scale pilot unit shows economical and satisfactory results, the commercial-scale plant will be built, it is understood.

★ ★ ★

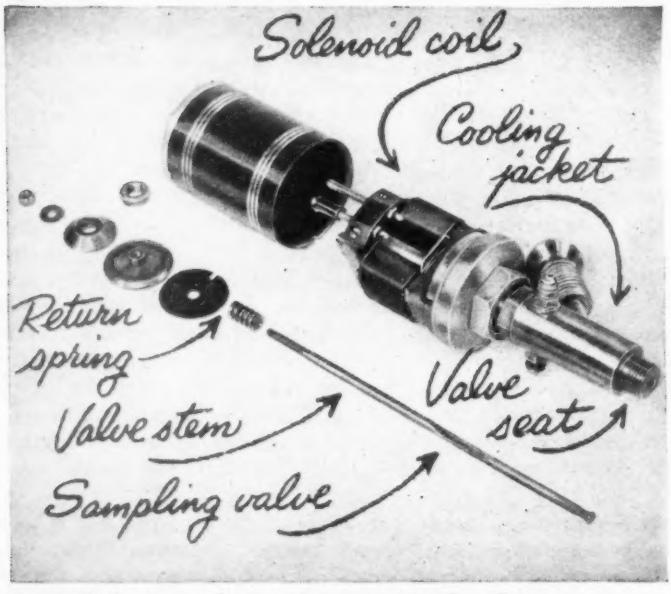
Crankcase Oil "Rogue's Gallery." A filter paper; a skilled technician; a specially selected indicator, and two drops of oil are the requirements for determination of the condition of a used lubricating oil, say Shell Oil Company experts. This new ADC Oilprint Analysis procedure has for its primary purpose the determination of the dispersancy (scattering of "foreign" matter through the oil) and contamination of used oils. It also determines the "basicity count," the rating of the oil as to its freedom from corrosive action; oils in use lose or destroy their alkaline additives and corrosiveness increases. Oil spot is placed on the absorbent (filter) paper and a drop of the indicator is added. The appearance of the resulting spot, interpreted by the man trained in this work, indicates clearly the oil's condition.

Main purpose of the test is to find out quickly optimum oil change periods, without expensive time-consuming operations.

XUM



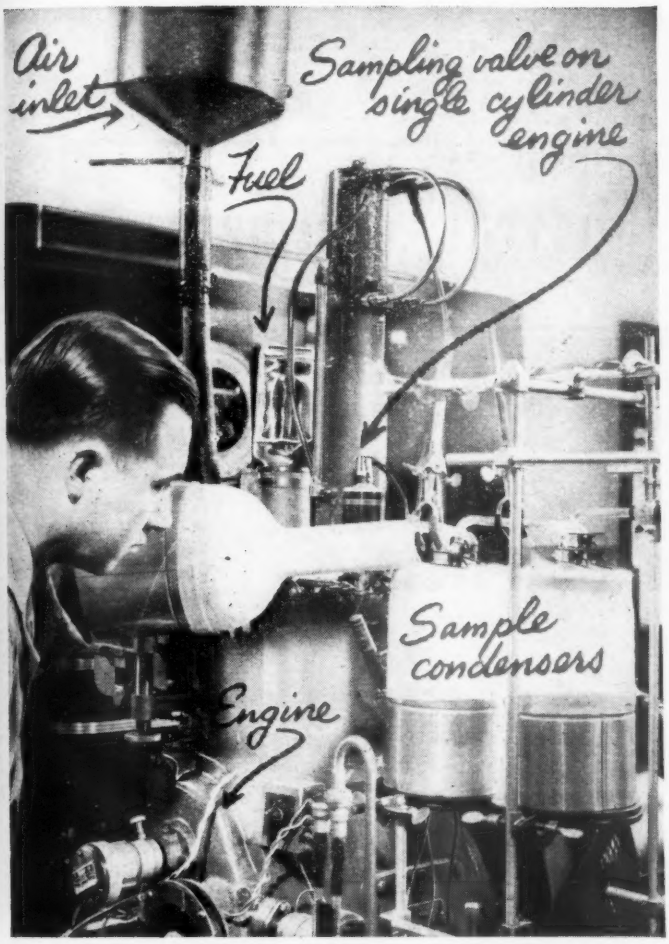
Special instrumentation enables Ethyl Research people to trace fuel distribution to each cylinder, and sample gases at a given moment during combustion. Samples are removed from the cylinders by carefully timed sampling valves.



Exploded view shows tiny electrically driven poppet valve, which is mounted in the cylinder head.

Less than 1/1,000 of a second is required for the sampling valve to open and close.

Heavy hydrogen put to work by Ethyl Research



High-speed sampling technique was developed on single-cylinder engines like the one shown above.

Mass spectrometer, developed by Consolidated Engineering Corp., analyzes the condensate, picking out the "tagged" atoms. This shows how the hydrocarbon mixture was distributed among the various cylinders.

One of the reasons why an engine knocks is this: all cylinders do not receive the same air-fuel mixture—and so distribution of hydrocarbons varies from cylinder to cylinder! Though this may cause knock to occur in only one cylinder, it can boost the antiknock requirement of the entire engine!

How much do the hydrocarbons in the mixture vary from cylinder to cylinder? And what can be done about it?

To track down the answers to these questions, Ethyl Research people assembled a special test apparatus. High-speed sampling valves were inserted in the combustion chambers of a conventional passenger-car engine so samples of the burned gases could be collected from all cylinders.

The test procedure works like this: Various components of the gasoline are "tagged," one by one, by replacing an ordinary hydrogen atom with an atom of heavy hydrogen. The special fuel is then burned in the engine. Samples of the burned gases from the cylinders are collected, condensed and then analyzed in a mass spectrometer. This machine records the presence of the "tagged" components and so gives Ethyl a picture of fuel distribution to the cylinders.

This is part of a program to help refiners manufacture gasolines that will distribute more uniformly from cylinder to cylinder and thus help them control one cause of knock on the road.

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XUM

PROGRAM

API Midyear Meeting

Jefferson Hotel
St. Louis, Missouri
May 9-12

DIVISION OF REFINING

Analytical Research

May 9, 1955, 9 AM — (Ivory Room)

Presiding: C. E. Headington, The Atlantic Refining Company. Session developed by Headington; and by G. R. Lake, Union Oil of California.

Introductory Remarks:
L. W. Moore, Sponsor for the Committee on Analytical Research; American Oil Company.

Spectrographic Determination of Nickel and Vanadium in Petroleum Products by Catalytic Ashing.
J. E. McEvoy, T. H. Milliken, Jr., and A. L. Juliard, Houdry Process Corporation.

Flame Spectra of 20 Metals Using a Recording-Flame Spectrophotometer.
Marvin Whisman and B. H. Eccleston, Bureau of Mines, U. S. Department of the Interior.

Determination of Trace Metals in Oils.
J. T. Horeczy, B. N. Hill, A. E. Walters, and H. G. Schutze, Humble Oil and Refining; and W. H. Bonner, E. I. du Pont de Nemours and Company, Inc.

An X-ray Spectrographic Method for the Determination of Vanadium and Nickel in Residual Fuels and Charging Stocks.
E. N. Davis and Barbara C. Hoeck, Sinclair Research Laboratories, Inc.

The Determination of Total Nitrogen in Reformer Charge Stock.
R. W. King and W. B. M. Faulconer, Sun Oil Company.

The Spectrophotometric Determination of Carbonyl Sulfide in Petroleum Refinery Gases.
F. J. O'Hara, W. M. Keely, and H. W. Fleming, The Girdler Company.

Trace Amounts of Total and Basic Nitrogen in Petroleum Distillates.
D. T. Fanale, R. B. Fricioni, D. W. Hutton, R. E. Snyder, and R. O. Clark, Gulf Research and Development Co.

Corrosion

May 9, 1955, 9:30 AM — (Gold Room)

Presiding: William Naden, Esso Standard Oil Company. Session developed by C. F. Pogacar, The Atlantic Refining Company.

Literature Survey of Corrosion in Cooling-Water Systems, 1940-1953.
H. F. McConomy, The Atlantic Refining Company.

Use of Neutralizers and Inhibitors to Combat Corrosion in Hydrocarbon Streams — A Report of the API Subcommittee on Corrosion of the Committee on Refinery Equipment.
R. J. Hafsten and K. R. Walston, Standard Oil, Indiana.

Deterrence of Hydrogen Blistering at a Fluid Catalytic Cracking Unit.
B. W. Neumaier and C. M. Schillmoller, Richfield Oil Corporation.

Cooling-Water Treatment Pays Off.
R. J. W. Dilliplane, J. J. Hur, and D. A. Wrigley, Atlantic Refining.

Corrosion of Concrete Condenser-Water Sewers.
John Zahodnick, Esso Standard Oil.

Analytical Research

May 9, 1955, 2 PM — (Ivory Room)

Presiding: G. R. Lake, Union Oil, California.
Session developed by C. E. Headington, The Atlantic Refining, and G. R. Lake.

Analytical Laboratory Operation and Control Utilizing Business-Machine Punched-Card Procedures.
L. M. Addison, E. H. Spencer, and E. M. Charlet, Esso Laboratories, Esso Standard Oil Company.

A New Look at the Composition of Lubricating Oil.
F. W. Melpolder, R. A. Brown, T. A. Washall, W. Doherty, and C. E. Headington, The Atlantic Refining Company.

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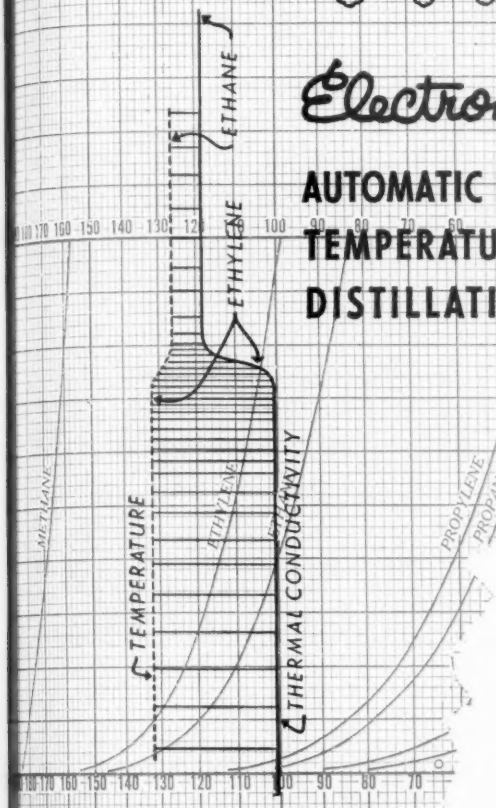

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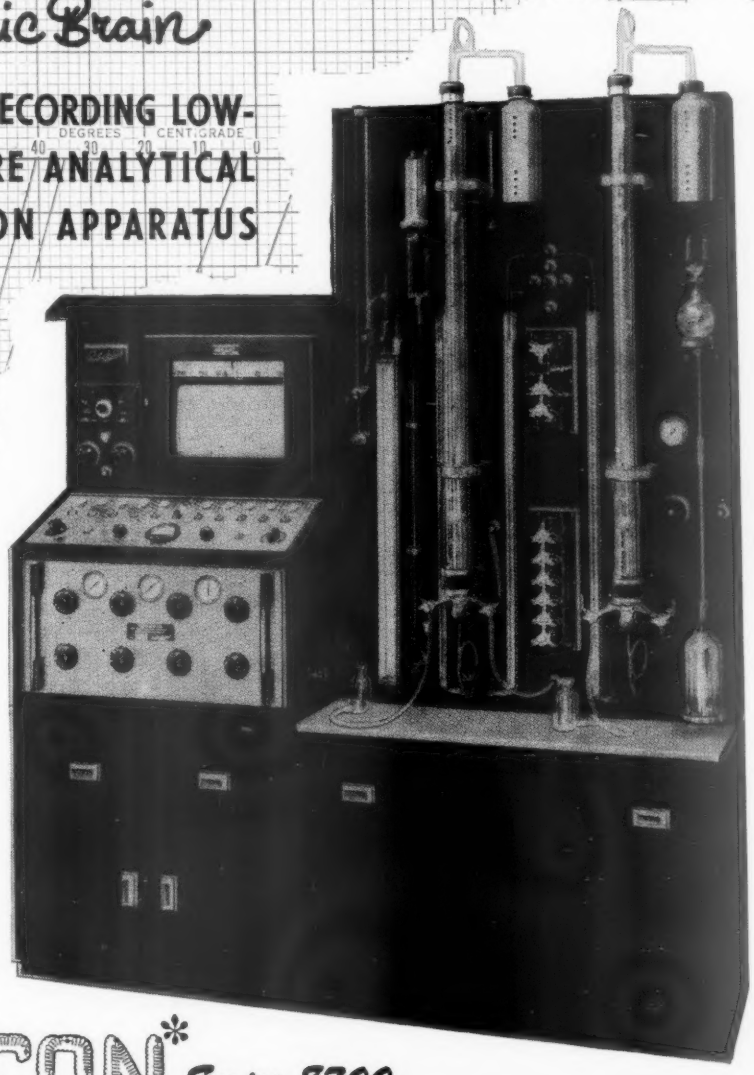

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Director
Division of Refining,
American Petroleum Institute
New York, New York

A Differential Infrared Method for Quantitatively Determining Specific Hydrocarbons.
C. W. Key and O. E. Eastin, Richfield Oil Corporation.
Determination of Six and Seven Carbon Naphthenes in Reformer Charge Stock — Report of the COAR Subcommittee on Determination of Naphthenic Hydrocarbons.
C. C. Martin and S. S. Kurtz, Jr., Sun Oil.
Colorimetric Determination of Low Concentration of Oxygen in Gases.
C. Stafford, J. E. Puckett, M. D. Grimes, and B. J. Heinrich, Phillips Petroleum Company.
Laboratory Methods for the Evaluation of Evaporation Losses of Petroleum Products.
J. Holowchak and E. L. Baldeschwieler, Esso Research and Engineering Company.
The Polarographic Determination of Elemental Sulfur in Crude Petroleum Oil and Its Fractions.
H. V. Drushel and J. F. Miller, Mellon Institute of Industrial Research; and Walter Hubis and R. O. Clark, Gulf Research and Development.
Analytical Distillation in Miniature Columns — II: Performance Under Total and Partial Reflux.
A. G. Nerheim and R. A. Dinerstein, Standard Oil of Indiana.

Training

May 9, 1955, 2 PM — (Gold Room)
Presiding: C. C. Tate, Phillips Petroleum Company. Session developed by E. R. Laminack, Socony-Vacuum Oil Company.
Supervision: Key to Effective Communication.
M. E. Stone, Sinclair Oil Corporation.
A Procedure for Training Process-Unit Operating Personnel.
O. C. Day, Esso Standard Oil Company.
Organization Planning in Relation to Management Development.
Lounsbury Fish, Standard Vacuum Oil.

Smoke and Fumes

May 10, 1955, 10 AM — (Gold Room)
Presiding: John W. Newton, Magnolia Petroleum Company. Session developed by Vance N. Jenkins, Union of California.

The Formation of Ozone in Polluted Atmospheres.
L. M. Richards, Stanford Research Institute.

The Concentration of Ozone in the Atmosphere of Certain American Cities.
J. Cholak, L. J. Schafer, and D. W. Yeager, The Kettering Laboratory, University of Cincinnati.

Reactions Involving Ozone, Nitrogen Dioxide, and Organic Compounds at Low Concentrations in Air.
Philip L. Hanst, Edgar R. Stephens, and William E. Scott, The Franklin Institute.

Product Control

May 10, 1955, 2 PM — (Gold Room)

Presiding: Harold G. Osborn, Continental Oil Company. Session developed by W. K. Bergen, Standard Oil of Ohio.

PANEL SESSION: New Horizons in Product Control.
T. Keith Glennan, panel leader, Case Institute of Technology; Russell L. Ackoff, Case Institute of Technology; Louis N. Ridenour, Jr., International Telemeter Corporation; Peter F. Drucker, Professor of Management, Graduate School of Business, New York University.

Pressure Vessels

May 10, 1955, 7 PM — (Gold Room)

Presiding: O. C. Johnson, Socony-Vacuum Oil Company, Inc. Session developed by N. J. Rees, Socony-Vacuum.

Considerations Affecting More Economic but Equally Safe Pressure-Vessel Construction Utilizing Either Present-Day Ductile Materials or New High-Strength Less-Ductile Materials.
J. J. Murphy, C. R. Soderberg, Jr., and D. B. Rossheim, The M. W. Kellogg Company.

Mechanical Properties and Weldability of Six High-Strength Steels Applicable to Pressure Vessels.
R. D. Stout and J. H. Gross, Lehigh University.

Graphitization of Steel in Petroleum Refining Equipment—Summary Report of the Subgroup on Deterioration of Steels at High Temperatures.
J. G. Wilson, subgroup chairman; Shell Oil.

Processes

May 11, 1955, 9 AM — (Gold Room)

Presiding: Bruce K. Brown, Pan-Am Southern Corp. Session developed by C. L. Thomas, Sun Oil.

Hydrogen—Its Markets and Potential Uses.
Robert L. James, Arthur D. Little, Inc.

Hydrogen from Catalytic Reformer Off-Gas.
Carl Pfeiffer and Henry J. Sandler, Catalytic Construction Company.

Improving Distillate Fuels by Hydrofining.
W. J. Zimmerschied, R. A. Hunt, Jr., and W. A. Wilson, Standard Oil of Indiana.

The Gulf HDS Process for Upgrading Crudes and Residues.
Jerry McAfee, C. W. Montgomery, J. H. Hirsch, and W. A. Horne, Gulf Research and Development; and C. R. Summers, Jr., Gulf Oil Corporation.

Fuels and Lubricants

May 11, 1955, 9 AM — (Ivory Room)

Presiding: W. J. Sweeney, Esso Research and Engineering. Session developed by T. B. Rendel, Shell Oil.

Autoignition of Fuels in a Constant-Volume Bomb — Effects of Operating Variables and Fuel Structure (Report of the Diesel Bomb Advisory Group of the CFR Diesel Fuels Division of Co-ordinating Research Council, Inc).
R. W. Hurn, Bureau of Mines; M. A. Elliot, Illinois Institute of Technology, and H. M. Trimble, Phillips.

A Survey of Hot-Fuel Handling Problems — A Report of the Trouble-Spot Surveys Conducted During the Summers of 1953 and 1954 by the CFR-MFD Volatility Group of Coordinating Research Council, Inc.
D. P. Heath, Socony-Vacuum; J. G. Moxey, Jr., Sun Oil; and G. Way, Ethyl.

Incentive for Precise Test Methods: The Case for a New Basic Knock-Test Unit.
M. R. Morrow, Humble Oil and Refining. (This paper will be followed by prepared discussion.)

Processes

May 11, 1955, 2:30 PM — (Gold Room)

Presiding: G. C. Cunningham, Shell Oil. Session developed by C. L. Thomas, Sun Oil.

Hydrogen Recovery and Purification from Refinery Off-Gases.
J. T. Hugill and F. G. Kerry, Spaco, Inc.

Hydropretreatment of Catalytic Reformer Feed.
D. H. Stevenson and G. A. Mills, Houdry Process Corp.

Unifining — A Proven Refining Technique.
G. H. Hemmen and A. E. Kelley, Union Oil of California; and M. J. Sterba and Davis Read, Jr., Universal Oil Products Company.

Vapor-Phase Hydrodesulfurization Applied to Cracked Naphthas and Light Straight-run Intermediates.
M. D. Abbott, G. E. Liedholm, and D. H. Sarno, Shell Development.

Processing of Heavy High-Sulfur Crude Oil in a Low-Sulfur Refinery.
W. H. Winslow, Esso Standard Oil Co.; and John Weikart, Esso Research and Engineering.

Open Dinner Session

May 11, 1955, 7 PM — (Gold Room)

Presiding: E. B. McConnell, vice president for Refining (American Petroleum Institute), Standard Oil Co. of Ohio. Session developed by C. E. Davis, Shell Oil Company.

Opening Remarks:
E. B. McConnell, vice president for Refining.

Presentation of the API "Certificate of Appreciation."
Recipients: E. L. Baldeschwieler and Albert E. Miller.

Refining — A Story of Progress.
Chester F. Smith, vice president, Standard of New Jersey.

Atomic Energy — Weapon for Peace.
Hubert N. Alyea, Professor of Chemistry, Princeton University.

Refinery Maintenance

May 12, 1955, 9 AM — (Gold Room)

Presiding: R. R. Irwin, Socony-Vacuum Oil. Session developed by D. R. Johnson, Continental Oil.

Planning and Building the Refinery for Minimum Maintenance.
R. E. Redfield, Socony-Vacuum Oil.

Scheduling Refinery Maintenance.
C. E. Gunter and W. D. Armintor, Gulf Oil.

Prepared Discussion: The Effect of Standardization on Maintenance.
Haylett O'Neill, Jr., Humble Oil and Refining.

Use of Contract Maintenance Crews for Large-Scale Refinery Turnarounds.
John W. Towler, Union Oil of California.

Petroleum Products

May 12, 1955, 2 PM — (Gold Room)

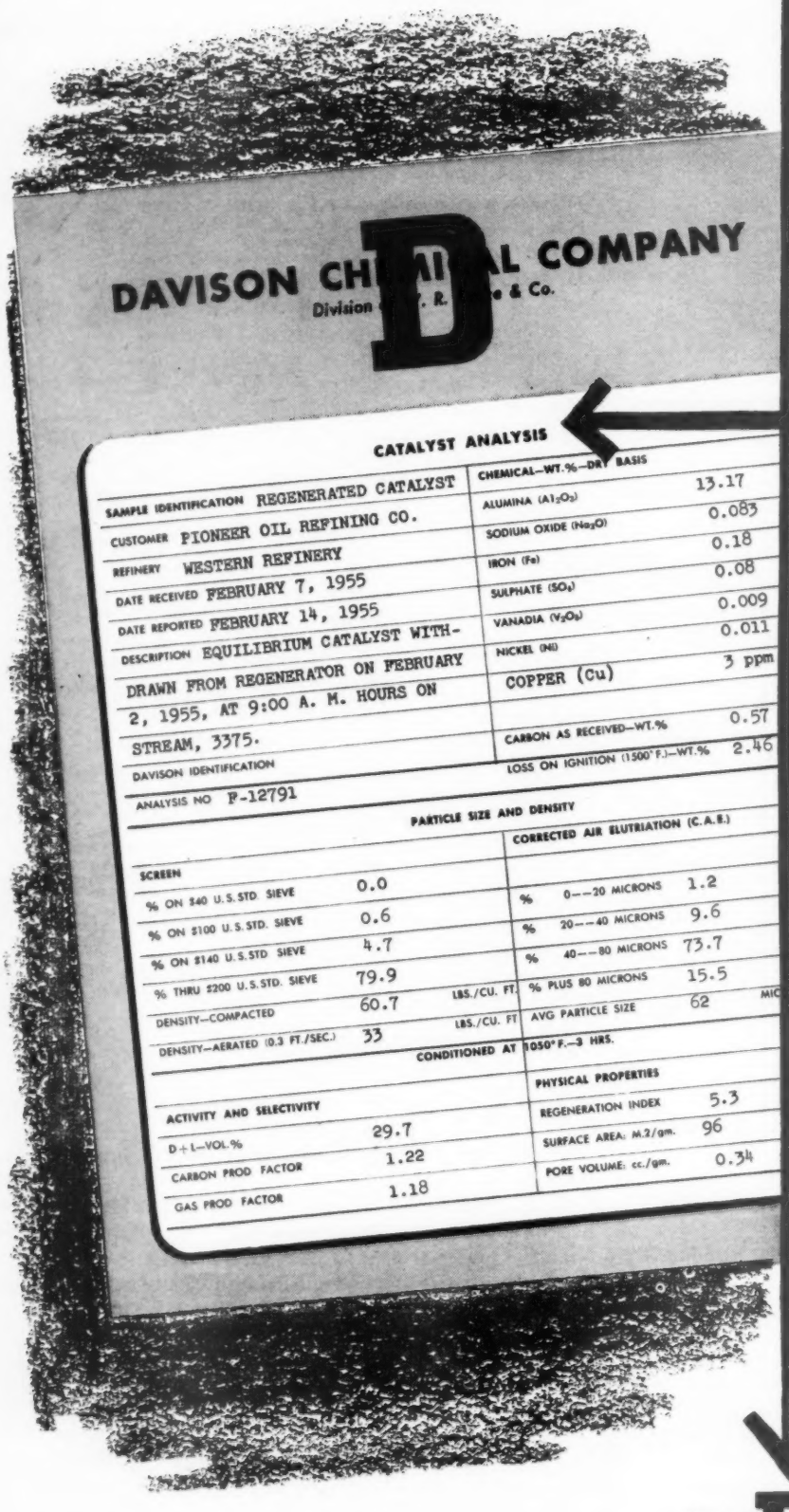
Presiding: H. E. Cotton, Standard Oil of Indiana. Session developed by P. C. White, Pan American Refining Corporation.

Protective Labeling of Petroleum Products.
L. C. Beard, Jr., and A. C. Pabst, Socony-Vacuum.

A New Look at Heavy Fuel Oils.
J. O. Collins and W. T. Knox, Esso Research and Engineering.

The Changing Product Demand on Our Refineries.
A. L. Lyman, California Research Corporation. * * *

Your guide to better Catalyst Performance


DAVISON CHEMICAL COMPANY
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CATALYST ANALYSIS
SAMPLE IDENTIFICATION REGENERATED CATALYST
CUSTOMER PIONEER OIL REFINING CO.
REFINERY WESTERN REFINERY
DATE RECEIVED FEBRUARY 7, 1955
DATE REPORTED FEBRUARY 14, 1955
DESCRIPTION EQUILIBRIUM CATALYST WITH-
DRAWN FROM REGENERATOR ON FEBRUARY
2, 1955, AT 9:00 A. M. HOURS ON
STREAM, 3375.
DAVISON IDENTIFICATION
ANALYSIS NO P-12791
CHEMICAL—WT.%—DRY BASIS
ALUMINA (Al_2O_3) 13.17
SODIUM OXIDE (Na_2O) 0.083
IRON (Fe) 0.18
SULPHATE (SO_4) 0.08
VANADIA (V_2O_5) 0.009
NICKEL (Ni) 0.011
COPPER (Cu) 3 ppm
CARBON AS RECEIVED—WT.% 0.57
LOSS ON IGNITION (1500° F.)—WT.% 2.46
PARTICLE SIZE AND DENSITY
SCREEN
% ON 140 U.S.STD. SIEVE 0.0
% ON 100 U.S.STD. SIEVE 0.6
% ON 140 U.S.STD SIEVE 4.7
% THRU 200 U.S.STD. SIEVE 79.9
DENSITY—COMPACTED 60.7 LBS./CU. FT.
DENSITY—AERATED (0.3 FT./SEC.) 33 LBS./CU. FT
CORRECTED AIR ELUTRIATION (C.A.E.)
% 0—20 MICRONS 1.2
% 20—40 MICRONS 9.6
% 40—80 MICRONS 73.7
% PLUS 80 MICRONS 15.5
AVG PARTICLE SIZE 62 MIC
CONDITIONED AT 1050° F.—3 HRS.
ACTIVITY AND SELECTIVITY
D+L—VOL.% 29.7
CARBON PROD FACTOR 1.22
GAS PROD FACTOR 1.18
PHYSICAL PROPERTIES
REGENERATION INDEX 5.3
SURFACE AREA: M.2/gm. 96
PORE VOLUME: cc./gm. 0.34

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INTRODUCING

Refining Fundamentals

Presented as the most informative and usable series for the practical refining man that has yet been compiled in the literature of the petroleum industry

The accompanying article is the first in an extended series designed to cover comprehensively the fundamentals of refining technology, chemistry, chemical engineering, processing, operation, and maintenance. When completed this book-length series will include important data and information on every phase of refining, including operations and processes in a modern refinery.

The articles are planned as a refresher course to bring up-to-date the refinery man who wishes to "rub up" on the newest technical developments in refining, to refresh his knowledge of the principles involved in all processing, operating, and maintenance phases of the refining of crude petroleum. It will present a thorough, practical education in refining for operating men who have not had formal education in the fields covered. When this series is completed, the reader who studies the articles will have a wide knowledge of the principles underlying refinery operations and much of the working details of processes. He will know the what and the why of the properties of the many products made in the refinery, their uses and applications, and the effects of different properties (specifications) of products on their performance.

This first chapter is a general introduction to the series, and discusses world data on crude production. The second chapter, also included in this article, discusses the occurrence of petroleum, how and where it is distributed in the earth, and the advantages given to nations by its possession.

Succeeding articles will discuss properties and types of crudes and their differences; and uses for different types of crude. The main subjects of the series will be presented in turn and in considerably greater detail than are these first introductory chapters. To obtain the maximum amount of information from the series the reader should start with this first chapter and continue through the succeeding chapters.

V. A. Kalichevsky

Author of

Refining Fundamentals

PETROLEUM

. . . its occurrence and distribution

Chapter I

PETROLEUM is the most important commodity in the world, next to those necessary to sustain life itself. Engine fuels, heating oils, lubricants, road-surfacing materials, illuminants, cleaning solvents, roofing compounds, paints, inks, mosquito oils, pharmaceuticals, and a large number of other diversified substances originate from crude oil. Present day civilization depends on the availability of petroleum and many international conflicts originated because of the importance of procuring the supply of this material for the present and future generations of a country.

Petroleum provides power. It is composed of two elements — carbon and hydrogen — that burn and produce energy on combining with the oxygen in the air. During this process huge quantities of heat are evolved and are utilized for generating useful work. Under ideal conditions, one gallon of petroleum heats 15 gallons of water from room temperature (70-80 F) to its boiling point and turns it into steam. A one-horsepower engine can run six hours on one pint of petroleum. Although only a fraction of this energy (15-25 per cent) is utilized in practice, this fraction is still very large compared to the quantity of petroleum consumed. A nation possessing vast quantities of cheap liquid fuel is thus in a commanding position with respect to its less fortunate neighbors both in peace and in war. Such a nation can keep turning the wheels of her factories and produce all the goods necessary to satisfy her wants and build a war machine against an aggressor.

Many ingenious methods were developed for refining petroleum, that is for purifying and improving it. Appearance of "high-octane" motor fuels, "heavy duty" lubricating oils, and other high grade materials stimulated development of new machinery that surpasses in performance the wildest dreams of the past and even of living generations. And the progress of civilization continues at an unabated pace.

The oil industry has numerous ramifications. Not only laymen but also technical people may have difficulty in understanding the odd terms that are encountered whenever petroleum is mentioned. Distinctions between processes such as polymerization, gas reversion, alkylation, or thermal and catalytic cracking might be obscure. The following chapters give a simple explanation of these terms.

The structure of the petroleum industry is complex. Every branch of science has a part in its development. This is necessary in order to supply people with products they want. A fully integrated petroleum company capable of providing the public with maximum service must consist of four well-defined units: Production, transportation, refining and marketing divisions. The fifth unit — the research division — keeps the company abreast of new developments. For highest efficiency the activities of these units must be coordinated without impairing their competitive spirit.

Competition is keen both inside and outside the industry. More than 40,000 enterprises are engaged in the petroleum business. Some 400,000 establishments are handling gasoline as compared to 600,000 food stores and 300,000 eating places. A motorist can cross the United States buying just one gallon of gasoline at a time. The product is available whenever it is needed.

Petroleum is not a pure substance but a very complicated mixture that the refiner must rework into uniform products meeting rigid specifications. The hydrocarbon molecules present in the crude oil show an infinite variety of structures. Some of them may or may not burn well in an engine, others may fail in providing proper lubrication or lack the properties demanded for a specific petroleum product. Petroleum chemists face the problem of separating the desired molecules from the undesirable ones, of transforming the inefficient into efficient molecules, of enhancing the valuable characteristics of products by the addition of chemicals. Heat, pressure, catalysts, solvents, physical, and chemical treating agents are employed for achieving these results.

For example, a catalyst induces a smooth reaction that would occur slowly if at all without its aid. A solvent dissolves one undesired substance and leaves the material wanted: Phenol takes asphaltic and resinous or olefinic materials from lubricating fractions and leaves the desirable (paraffinic, etc.) hydrocarbons. A physical treating agent, like a filter clay, takes out impurities like coloring matter and leaves the purified oil. A chemical treating agent like sulfuric acid take out impurities like sulfur or unsaturated hydrocarbons, and leaves the refined oil.

Hydrogen may be added to the molecules containing an excessive number of carbon atoms or the original molecules may be broken apart and their fragments recombined into new molecules. All these processing schemes find applications in the manufacture of high-grade products.

The first step in preparing salable materials from the crude oil is distillation. This is done by applying heat and boiling off the materials which then are condensed and segregated for reprocessing. The first major product obtained from the stills is known as "straight-run" gasoline. Then the next higher boiling product, kerosine, is collected. Heating is continued until the highest boiling component is distilled off. The remainder is either asphalt, wax, or a combination of the two, depending on the source of the crude oil. The quantity of heavy oil left in the residue is related to the product manufactured. The various substances thus obtained are called "fractions" or "cuts" and the process is known as fractional distillation. The principal fractions obtained on heating petroleum are gasoline, naphtha, kerosine, lubricating oil, fuel oil, and residuum. Sometimes heating is continued until residuum decomposes ("cracks") into coke, gas, and liquids.

Market demand does not correspond to the relative quantities and quality of these "virgin" petroleum fractions present in the crude oils. This can be corrected by processing the crude fractions at the refinery. Lighter fractions can be obtained from the heavier distillates by cracking. Gases may be converted into liquids by combining the small molecules into larger ones.

By their research efforts and ingenuity petroleum chemists have succeeded in doubling the quantity of usable materials recoverable from petroleum and none of the crude oil is wasted as was a common practice in the past. All of the raw materials must be utilized to best advantage by the refineries to show profit.

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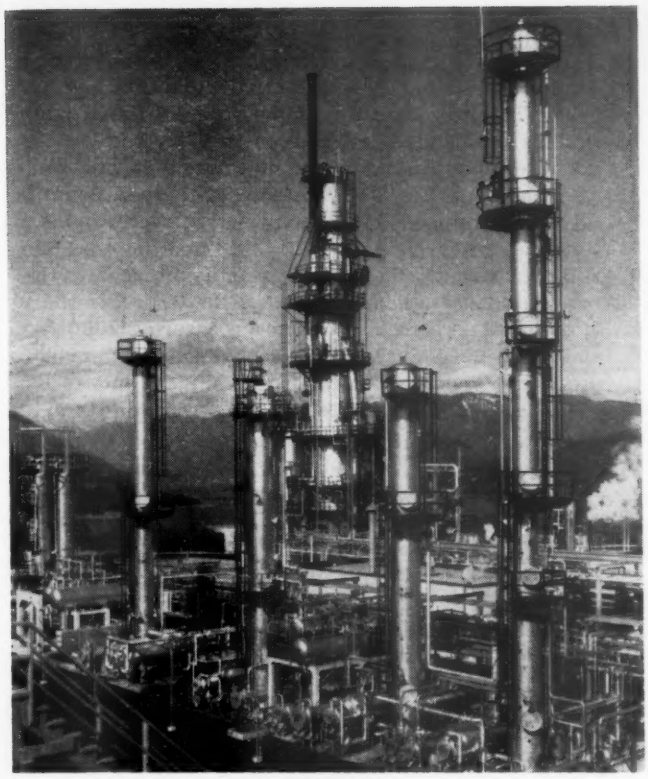


Milestone in industrial expansion in British Columbia was marked when Shell Oil of Canada Ltd., completed its $10,000,000 extension program at Shellburn Refinery. The refinery now handles 15,000 bbl of crude oil per day, an increase of 6000 bbl per day as compared with former operations. The new distillation system that is used to recover the gases from lighter refinery products is shown. In the background is the cracking unit.

Chapter II

History of Petroleum

The petroleum industry is one of the largest and best organized in the world. For many years the United States has maintained an unquestionable leadership in all its branches and her position remains unchallenged. The production of crude oil in this country rose steadily from 2000 bbl per year in 1859 to 2,000,316,000 bbl in 1954 and is still growing. For a long while the United States supplied two-thirds of world production and is still responsible for one-half of the total crude oil output. Notwithstanding this tremendous drain on our natural resources the known reserves of recoverable oil continues to increase in this country.

Since the first well was drilled in 1859, more than 1,000,000 wells have been sunk and each year adds some 50,000 wells to this total. Four hundred thousand wells are still producing although many of them, known as "strippers," may yield as little as half a barrel of oil per day. Production of natural gas is estimated at over ten trillion cubic feet or seven cubic miles per year. Refining facilities are more than ample for reworking these huge quantities of crude oil into marketable products, and large research and development departments of the major oil companies are constantly at work to raise the quality of the finished materials. The total U. S. refining capacity for 1955 is more than 8,000,000 bbl per day.

The total capital investment in the petroleum industry in this country is estimated at forty-four billion dollars and the total assets at over forty-three billion dollars. Of the investment 58 per cent is in production, 18 per cent in refining facilities, 11 per cent in marketing, and 12 per cent in transportation. The capital expenditures in 1953 were four billions in this country in addition to half a billion abroad.

The petroleum industry employs 1,700,000 people in the United States. Their average weekly earnings are higher than those of the workers engaged in similar capacities by other industries. *The total wages of these oil workers are less than the taxes paid by the oil companies.*

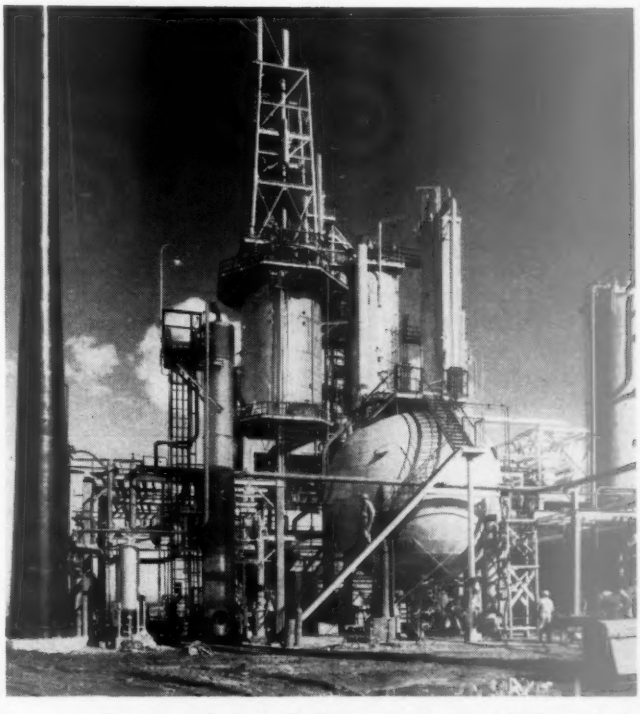
In the United States 64 per cent of the total energy used for heating and power generation is derived now from petroleum and natural gas. This compares with 43 per cent in 1940. Per capita consumption of petroleum in the United States is *more than thirty times* the average for the rest of the world. Each person in this country, directly or indirectly, uses 16 bbl of oil per year (672 gal).

Petroleum production in this country made possible the development of the huge automotive industry. Possession of a car became a necessity and not a luxury for most American families. Half of the communities in the United States are wholly dependent on highway transportation and the average motorist travels more than 8000 miles per year. In 1953 some 56,000,000 motor vehicles were on the road—one vehicle for each three persons living in this country. The rest of the world, which comprises 20 times as many people, had only 27,000,099 vehicles at their disposal or one-half of the United States total; or one-fortieth of the number of vehicles per person.

Distribution of Petroleum

Petroleum is found in nearly 50 countries. The absence of oil fields in some portions of the globe may be traced, not to their absence necessarily, but to the lack of incentive for thorough explorations in remote regions, restrictions of personal initiative, or the inertia of local inhabitants. For years the presence of oil reserves was not even suspected in such long-established centers of population as Austria, France, Germany, or Italy. Only recently the existence of these reserves was established and their development started. At the present time crude oil is produced in the following portions of the world:

1. **NORTH AMERICA** produces 53.4 per cent of world's petroleum. The United States supplies 93 per cent of this volume or 49.7 per cent of world's total. Canada



Towering 15 stories high against the North Dakota sky is the 172-ft cat cracker of Standard Oil's new Williston Basin refinery at Mandan. The surface area of the 175 tons of fine particles of clay that flow through this catalytic cracking unit would equal that of half of North Dakota.

XUM

supplies 3.2 per cent, Mexico 2.9 per cent, Trinidad 0.88 per cent and Cuba 0.02 per cent. This 0.02 per cent still represents 36,000 bbl of oil.

Petroleum fields in the United States may be divided into Mid-Continent, California, Gulf Coast, Eastern, and Rocky Mountain. They supply the oil in approximate quantities of 56, 20, 15, 6 and 2 per cent, respectively. Based on this Texas leads by far all other states, supplying more than 43 per cent of the country's total. California is the second largest producing state, accounting for 15 per cent of our crude oil. Petroleum has been found in 27 states. The quantities of oil discovered in Virginia, Missouri, and Tennessee are very small as yet, however. The oil fields of Canada are expanding rapidly and recent attempts to drill wells in Northern Alaska may lead to the discovery of new oil deposits.

2. **SOUTH AMERICA** supplies 15.5 per cent of the world's crude oil. Venezuela produces 88 per cent of this oil, Colombia 5 per cent, Argentina 4 per cent, Peru 2 per cent, and Ecuador, Chili, Brazil and Bolivia less than 0.5 per cent each.

3. **EUROPE** contributes 9.4 per cent of petroleum. After excluding USSR and her satelites, however, this figure is reduced to 0.6 per cent or 68,000 bbl per day. Germany supplies 62.5 per cent of this latter quantity, Netherlands 23 per cent, France 10.3 per cent, Italy 2.6 per cent, and England 1.6 per cent. Much exploratory work is carried on in Italy and France.

4. **ASIA** accounts for 21.2 per cent of world's production. Kuwait supplies 31 per cent of this volume, Saudi-Arabia about the same quantity, Iraq 21 per cent, Indonesia 7.6 per cent, Sarawak and Brunei 3.7 per cent, Qatar 3.1 per cent, Bahrain Island 1.1 per cent, and Persia, India, Japan, Turkey, and China from 0.94 to 0.07 per cent each.

The low production in 1953 in Persia was due to the severance of economic relations with England. Difficulties concerning the royalty payments were smoothed out, however, and the Persian oil will reappear on the market. In 1950 Persia supplied one-third of the oil arising in Asia or 6.5 per cent of world's total.

5. **AFRICA** produced 0.5 per cent of petroleum. Ninety-five per cent of this quantity was obtained from Egypt, 4.4 per cent from French Morocco, and 0.6 per cent from Algeria. Search for the new oil fields continues.

6. **AUSTRALIA AND SOUTH SEA ISLANDS** are still waiting for the discoveries of rich oil fields. Very small quantities of petroleum have been found in New Zealand, Australia, and New Guinea, but explorations are in progress.

Petroleum oil fields are often far from centers of consumption and some continents must supply the needs of others. Countries behind the iron curtain do little trading with the free world. They produce and consume 9 per cent of the world's petroleum, which is a relatively small quantity. The production figures presented in Table 1 refer only to the free world's countries.

TABLE 1. Relative production and consumption of petroleum in 1953 by the free world.

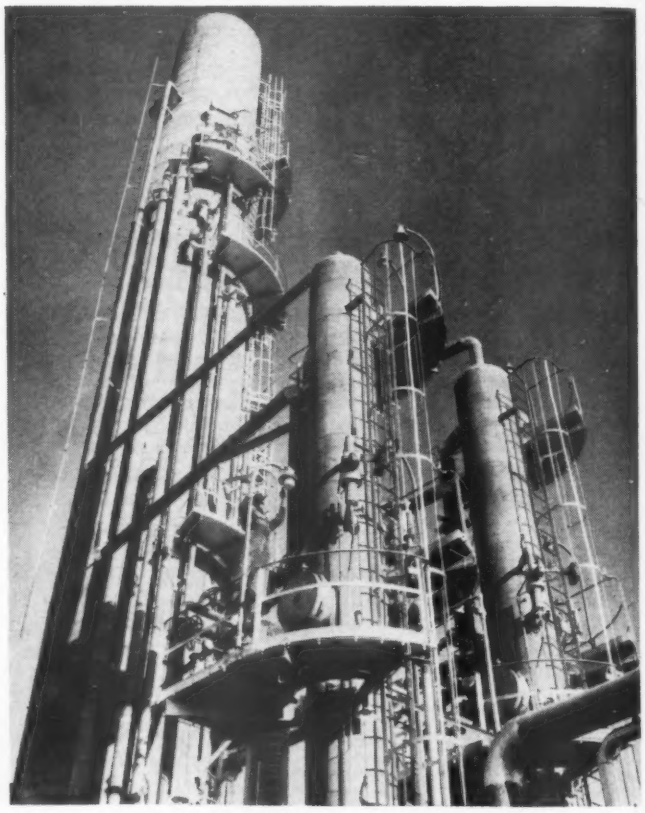
Continent	Production, per cent	Consumption, per cent
North America	58.7	72.9
United States	(54.7)	(64.5)
South America	17.0	4.9
Europe	10.6	13.8
Asia	23.2	4.3
Africa	0.5	1.9
Australia and Oceania	—	2.2
Total	100.0	100.0

Table 1 shows that Asia and South America supply the rest of the continents with crude oil. The United States can still meet the domestic demand by increasing oil flow from available wells. This is important if war breaks out.

History

Petroleum, asphalt, natural gas were known for thousands of years but their extensive exploitation is quite recent. The late realization of the value of these natural resources is difficult to explain, particularly because they are not rare minerals and are found in many localities.

Asphalt was the first substance of the petroleum family discovered by man. The asphalt deposits are often exposed to the air or barely covered by the superimposed layers of soil. Occasionally they form virtual lakes, such as the famous Trinidad asphalt lake, one of the largest in the world. It occupies an area of 115 acres, measuring 2000 ft across and 135 ft deep. Such natural asphalts are not alike in their properties and are known under different names like gilsonite, grahamite, elaterite, albertite, wurtzilite, and others.



Crude oil towers of the atmospheric distillation plant at Kwinana Oil Refinery. Two distillation units here will have a capacity of 1,500,000 tons.

Depending on trade requirements, asphalts of widely different characteristics can be obtained from nature or prepared artificially from petroleum residue to satisfy the diversified demand of the present day industry.

Natural gas was the second substance of the petroleum family to attract attention of our distant forefathers. Years before the advent of the Christian era, fire-worshippers, disciples of Zoroaster, were building temples in the Caucasus, defying the mysterious flame emerging from below the earth's surface. This flame was produced by natural gas escaping from under ground and set afire, possibly by lightning. Gas wells up to 2000 ft deep were drilled in China at the beginning of the seventh century, A.D., and the escaping gas used for lighting and heating. In Europe natural gas was first used for lighting and heating in Genoa, Italy. In the United States a gas well 27 ft deep was utilized by the city burners at Fredonia, New York, in 1821. However, natural gas became of real economic importance only in the last quarter of the nineteenth century.

THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE

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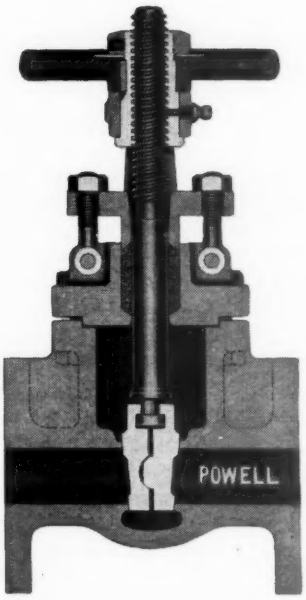

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FIG. 2495 (Sectional)—Stainless Steel O. S. & Y. Gate Valve for 150 Pounds W. P. Double Wedge Disc is accurately guided to seat.

FIG. 375—Bronze Gate Valve for 200 Pounds W. S. P.

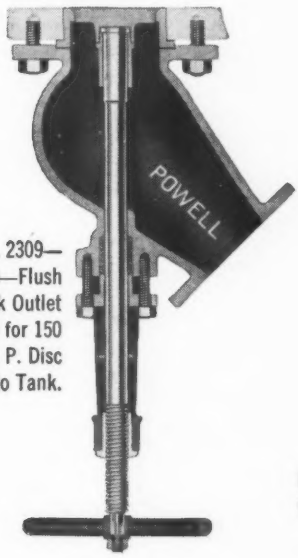


FIG. 2309—(Sectional)—Flush Bottom Tank Outlet Valve for 150 Pounds W. P. Disc Opens Into Tank.

FIG. 2193—Large Ni-Resist* Gate Valve for 200 Pounds W. O. G.

*Trade-mark of The International Nickel Co.

POWELL VALVES

Petroleum in its liquid form has been known for centuries through ground seepages. The Greek and Roman worlds were acquainted with it; references to it are to be found in the Bible. Some Polish towns used oil for street lighting in the sixteenth century. Petroleum was collected from ground seepages in a primitive manner, however, and the experiment was soon abandoned.

Russia was the first country to exploit petroleum commercially. A small plant, predecessor of modern refineries, operated in the 1820's near Baku and supplied the local market with illuminating oils. Petroleum was collected from hand-dug pits and seepages. The plant was abandoned after a few years of operation but others opened soon afterwards. The first records of commercial production of petroleum were compiled in 1857 by Romania and in 1859 by the United States.

Petroleum was first separated into fractions in 1788 by Winter.[1] When he placed crude oil in a flask and heated it, he noted first the appearance of a gas. He assumed that this gas was the evasive phlogiston, a hypothetical substance of the eighteenth century chemists. Then he collected a light liquid. The first real distillation of petroleum was conducted in 1798 by Hatchett who separated it into several fractions but did not know what to do with them. When in 1814 the first flowing oil well was discovered in Kentucky, it was abandoned because of the absence of demand.

In the United States petroleum was known for years as "Seneca Oil." It was gathered from ground seepages in regions inhabited by the Seneca Indians, an Iroquoian tribe of North America which called itself Tshotinondawag or "people of the mountain." Existence of petroleum in America was first mentioned in 1627 by the Franciscan missionary, Joseph de la Roche d'Allion, who visited this country and learned about the existence of petroleum from the Indians.

Commercial utilization of petroleum began to make rapid strides with the invention of a lamp by Abraham Gesner, a Canadian geologist, in 1846. The lamp was designed for fuels obtained from oil shale but was well suited for utilizing petroleum distillates. The importance of this invention is overshadowed by the later rapid developments of the industry and it is difficult to realize the full meaning of this invention to our forefathers. Invention of a lamp which could be used at a very small expense was revolutionary.

Gesner's invention paralleled intensive studies of Professor Benjamin Silliman, of Yale University, on petroleum distillates and the possibility of using them as light sources. He was an ardent advocate of their acceptance by households and greatly contributed to the success of the petroleum industry in the first stages of its development.

August 27, 1859, is the official date of birth of the petroleum industry in the United States. On that day "Colonel" Edwin L. Drake completed the first oil well at Titusville, Pennsylvania. The well was 69½ ft deep and produced 20 bbl of oil daily. With the market ready to absorb this initial production at a fair return on the investment, the first oil boom in history was on. (In 1859 the quantity of oil produced was 2000 bbl; this figure rose to 500,000 bbl in 1860 and to over 2,000,000 bbl in 1861. Soon the quantity of oil obtained from under the ground could not be absorbed by the existing meager refining facilities, and in three years the price dropped from $20 to 10 cents per barrel. By that time, however, the usefulness of petroleum, both as an illuminant and a lubricant, was well established, and after the supply of raw material was assured, new refineries quickly sprang into being.

While kerosine was the chief refinery product for a number of years, its importance declined at the beginning of this century when the rapid growth of the automotive industry developed a large demand for gasoline, formerly a waste product. In 1900 gasoline production was only 7,000,000 bbl *per year* as compared to the present annual figure of 1,300,000,000 bbl, (3,570,000 per day) a two-hundred-fold increase. The present demand for kerosine, which includes such uses as fuel for diesel engines and tractors, is not over ten per cent of the total gasoline demand. The consumption of distillate fuel oil by domestic burners has increased rapidly since 1930, however, and is now five times greater than the demand for kersosine.

The total quantity of oil recovered from underground is 80,000,000,000 bbl, a volume equivalent to more than two cubic miles. Over 60 per cent of this oil was produced in the United States.

The last member of the petroleum family is mineral wax. This wax known as ozokerite was discovered in 1833 in the Carpathian Mountains. Since then other similar deposits were found and are known under the names of hatchettite, scheererite, etc. These names are useful for differentiating between the properties of individual deposits. In this country ozokerite is found in the far western states. Mineral waxes are employed in the manufacture of candles, colored pencils, polishes, and similar products. Another type of mineral wax, known as montan wax is extracted from lignite, a variety of coal, and is not of petroleum origin.

(The next chapter will appear in an early issue.)

The Author

Dr. V. A. Kalichevsky has such an extremely wide grasp of and experience in the petroleum refining industry, its technology, chemistry, and engineering that any work he may do is worthy of the close attention of every person interested in these phases of the industry. His activities have ranged from the highest levels of forward-looking research to the smallest details of operating techniques and everyday methods for making products and controlling processes.

His refining, technical, and scientific experience which furnishes a background for preparation of this book-length Refining Fundamentals work, started about 1924. During the following five-year period he was research chemical engineer for Union Oil Company of California. From 1929 to 1931 he was research chemist with Standard Oil Development Company. Then followed a six-year period as section supervisor in Socony-Vacuum's research and development department. Promoted to general supervisor of that department for Socony, "Dr. Kali" broadened his experience and knowledge for seven years in that position. When, in 1944, Magnolia Petroleum Company (Socony-Vacuum affiliate) was in need of a consulting engineer to oversee its technical operational activities, he was selected for the position he now holds.

Important details of his personal and professional history may be found in numerous publications such as *American Men of Science, Who's Who in Engineering, Builders of the Chemical Century,* and others. He is one of nine mentioned in the 1953-54 *Leaders in American Science.* The list of books authored and co-authored by him include *Modern Methods of Refining Lubricating Oils* (1938); *The Amazing Petroleum Industry* (1942); *Chemical Refining of Petroleum* (with B. A. Stagner, 1933, 1942); *Biografia de Petroleo* (Italy, 1952). His latest book, *Petroleum Refining Agents, was co-authored* with Dr. K. A. Kobe and is now in the process of publication.

In addition to these bound works, Dr. Kalichevsky has published at least 60 articles on petroleum, its properties and refining methods. As the result of his research a score of patents have been issued to him.

His professional affiliations attest to his diversity of interest and attainments. He is a full-fledged member of the American Institute of Chemical Engineers, the American Chemical Society (two of his books are ACS Monographs), The American Association for the Advancement of Science, the American Petroleum Institute, and The Texas Academy of Science.

Reviewing the history of Dr. Kalichevsky's long experience in refining technology, it is obvious that his experience in every phase of this field has given him comprehensive knowledge of every process and problem in the refining field. He has worked with every possible "trouble" in the field from the scientific development of a proper catalyst for a given purpose, to the choice, selection, and repair of a ⅛ in. valve in a pilot plant transfer line. He has wrestled with the paraffin wax in an extremely high pour point crude and has successfully solved the problem of moulding and packaging water-white wax for "the carriage trade."

This experience and training in the refining technological field makes Dr. Kalichevsky especially capable in the presentation of this refresher course in Refining Fundamentals.

Hydrocarbon analysis made more accurate, speedy

The use of Thermal Conducticity Cell and "Electronic Brain" permits greatly improved accuracy, higher speed in analysis

Walter J. Podbielniak*
and S. T. Preston*

LOW-temperature Fractional Distillation Analysis, or "LTFDA," needs little introduction at this time. Rose's recent thorough review of the method[15] comprises 92 pages and includes a bibliography of 72 technical papers, exclusive of patents. While LTFDA has found its greatest application in the petroleum industry on hydrocarbon materials, it is interesting to note that Rose lists over 200 compounds, boiling between liquid air temperature and 35 C, susceptible to analysis by this method. Included in this group are acetylene, chloro-fluoro compounds, oxygenated compounds, and many other non-hydrocarbons now produced in the "petrochemical" as well as chemical industries.

Why greater accuracy?—As with most other analytical methods of comparable scope and versatility, the accuracy attainable with LTFDA varies with the type of sample, the specific design and condition of the apparatus used, the analytical technique, and the intangible "human element" as discussed by Podbielniak.[8]

Since LTFDA has become practically standard in the petroleum, petrochemical and synthetic rubber industries, considerable attention has been given by many government and industrial technical groups toward determining the agreement attainable between different laboratories and toward increasing the accuracy of the method by improvement and standardization of operating techniques. Among these groups are the National Bureau of Standards working through Subcommittee VII of Committee D-3 of ASTM, the Rubber Reserve Corporation,[18] Petroleum Industry War Council,[9] a number of major petroleum companies,[1, 2, 16, 20] the California Natural Gasoline Association and especially the Natural Gasoline Association of America.[5, 6]

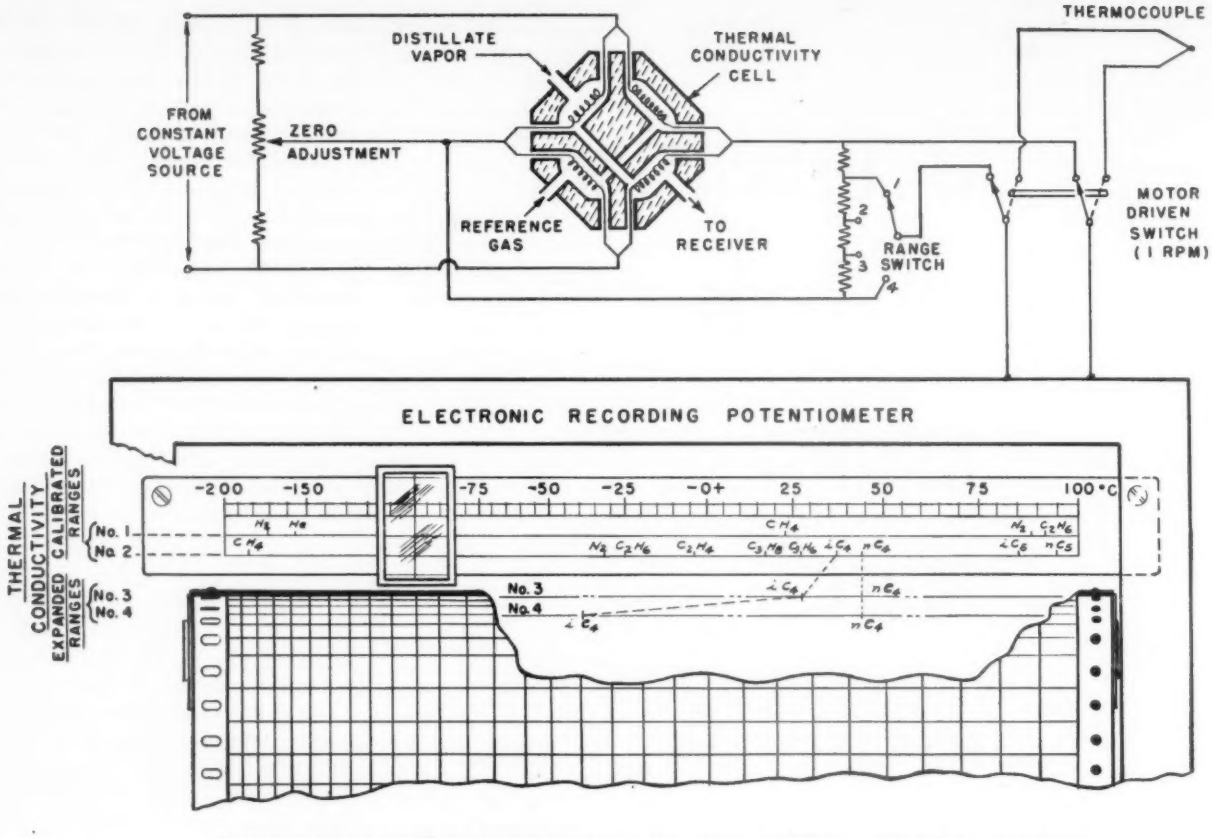
The latter has for many years not only conducted surveys in which up to 85 laboratories cooperated in analyzing synthetic "unknown" hydrocarbon samples, to determine incidence and causes of error, [3,4] but has actually conducted a special Low-Temperature Analysts' Training School at the University of Oklahoma,[7] from September 1952 to June 1953. Statistical study of the results of the cooperative analytical surveys,[11] pointed out many of the common causes of error, such as lack of correction for vapor holdup above column thermocouple, uncertain reflux liquid holdup corrections, incorrect calibrations and calculations, inadequate reflux ratios, poor location of thermocouple and others. The LTAT school served not only to correct and sharpen the techniques of its already experienced analyst students, but also functioned very effectively as a clearing-house between analysts, apparatus designer and NGAA on correlation of apparatus design, physical constants and calculation standard and best analytical techniques.

N.G.A.A. is continuing its cooperative analytical survey, and completing a comprehensive Manual for LTFG analysts, to continue improving industry-wide accuracy by these means. It has also seemed most desirable for the manufacturer to contribute to this objective by improving the *apparatus* itself, by 1) eliminating "Analytical Enemy Number 1" or reflux liquid holdup; 2) greater automaticity, to place less dependence on training and skill of analyst; and 3) introducing a large number of specific improvements in apparatus and its operating controls, many suggested in LTAT School round-table discussions.

Experiments to minimize or eliminate error due to variable liquid holdup in column reflux—In all Low-Temperature Fractional Distillation Analysis (LTFDA) apparatus, there

*Podbielniak, Inc., Chicago, Illinois.

EXCLUSIVE



"THERMOCON" RECORDING AND MULTIPLE SCALE SYSTEM

FIG. 1. Thermocon recording and multiple scale system

is a "pipe line" holdup of *vapor* between the expansion stopcock or valve, beyond which the cumulative *quantity* of the distillate is measured, and the thermocouple junction tip, which indicates the *identity* of the distillate and also the "break" or transition point between separated components. While this vapor holdup may amount to as much as 15 cc, it is relatively simple to correct for it by calculations,[12] to within only one or two cc residual error.

The above calculation does not account for the liquid condensate which wets the thermocouple and the walls of the distilling tube *above* the thermocouple tip, in a so-called "wandering upper condensation ring."[8] One cc of liquid hydrocarbon is equivalent to approximately 225 cc in the vapor phase at its boiling point. Therefore, the liquid film on the distilling tube 1 to 3 cm above the thermocouple can amount to from 20 cc to 65 cc *additional* "pipe line" vapor equivalent. This is practically impossible to correct for satisfactorily, because of its variability with column heat input, boiling point, boiling point difference of hydrocarbons distilled, distillate rate, etc. The resulting uncertainty in determining exact breakpoint, i.e., as between 20 cc to 65 cc, obviously corresponds to a substantial and erratic percentage error for the size samples usually taken in LTFDA; it well deserves to have the finger put on it, as "Analytical Enemy No. 1."[8]

Although a great deal of experimental work has been done for many years in the endeavor to stabilize and minimize the "wandering condensation ring" above the thermocouple, little success was gained, except with a complicated commutated multiple spaced thermocouple arrangement[8] which did not prove practical. The following were also tried:

1. *Various Liquid Nitrogen Vaporizers*—Literally a hundred or more different designs were tried, in the aggregate, with the objective of stabilizing "wandering upper condensation ring" to either just at the thermocouple junction or at least to a fixed location above. They ranged from complicated shapes intended to vary distribution of evaporative and sensible heats of liquid nitrogen in special ways, to a simple "cork" vaporizer used with sensible heat only. None solved the problem satisfactorily.

Special Analysts' Training School

A specialized training school for analysts will be opened by Podbielniak, Inc., late this summer or early fall, at 632 North Dearborn St., Chicago, it is announced. The location and time of opening of the school has been changed from the announcement made last November, the change being due to obtaining much better quarters and accommodations at the address given above. This school will be known as the Podbielniak Institute.

Training courses will be given to operators interested in analytical distillation techniques that have been developed by the company, particularly in the principles, theory and practice of low temperature distillation analysis. The curriculum will be extended to include discussions and classes of the "Pod" centrifugal principle of solvent extraction. Training will include a great deal of information not found in textbooks or current handbooks. Courses will last for two weeks, probably, although final decision had not been reached at press time. The institute is intended among other objectives to continue the excellent work of NGAA. Low-Temperature Analysts' Training School held at Norman, Oklahoma, from September, 1952, to June, 1953.

2. *Reflux Distilling Tube Modifications*—On the theory that condensate would not form in a suitably insulated upper section of the distilling tube, air-jackets, silvered or unsilvered were tried, including small bores, 2.5 to 3.5 mm, in such sections.[8] It was hoped that if the thermocouple junction were located just below such an insulated section, condensate could not possibly rise above this point. But a pronounced tendency for condensate to flood within such insulated sections discouraged further experimentation.

3. *Re-Analysis Techniques* — Accepting the reflux liquid holdup situation as an unavoidable evil, many apparatus and techniques were worked out for physical collection of the distillate fraction immediately before and after the break, and re-analyzing it as a binary mixture, by determining its vapor pressure,[17] re-distilling it in a special smaller column,[17] or by determining its thermal conductivity.[13] These methods accomplished their objective of increased accuracy but at the cost of more complicated, laborious and exacting apparatus and techniques.

4. *Use of Larger Samples* — Obviously, the percentage error introduced by variable reflux liquid holdup could be minimized by charging much larger samples into the column. To avoid proportional increase in distillation time, *larger diameter, high capacity* Heli-Grid packed distilling tubes, kettles and vacuum jackets were developed.[8] This is a practical method of minimizing this type of error, especially when the analyst is careful to keep his column "lean" with reflux liquid, and when at least an approximate correction is made for the reflux liquid holdup.[8]

Identification by Thermal Conductivity

It had long been realized, of course, that the root of the trouble lay in the use of the dew point method of determining identity of distillate, requiring considerable liquid at precisely dew point temperature to wet and warm the thermocouple, affected by radiant heat, etc. Other methods of identifying distillate, in vapor phase, such as determining a) dielectric constant, b) refractive index, c) specific gravity, d) infrared characteristics, and e) thermal conductivity, were considered. Of all these, the determination of thermal conductivity appeared to be the most suitable, because of its fundamental simplicity, low volumetric cell holdup requirements and room temperature operation.

The first experimental work on identifying distillate by thermal conductivity instead of dew point in LTFDA was done at the University of Texas, 1951 to 1952, by S. T. Preston, as a part of the research program of the Texas Petroleum Research Committee, under its director, Professor G. H. Fancher. A modified commercial cell was used, suitable circuits developed, and considerable progress made in the project. Experimental thermal conductivity cells were demonstrated by Preston at the NGAA Low Temperature Analysts' Training School at Norman, Oklahoma.

Since 1953, the authors and their associates at Podbielniak, Inc., have worked intensively on the development of a thermal conductivity cell, circuits and associated components to meet the following stringent but obviously necessary requirements of LTFDA: 1) Low vapor holdup, about 2 cc; 2) Sensitivity high enough to distinguish propylene from propane, isopentane from n-pentane; 3) Non-critical as to flow, within usual LTFDA distillate rate limits; 4) Without significant lag in following rapidly changing distillate composition; 5) Relatively insensitive to pressure changes, and 6) Stable and free from drift. Add to this the desirability of retaining the usual temperature curve, to be simultaneously plotted in some way with the thermal conductivity curve, and the magnitude of this development project can perhaps be appreciated.

The final cell and its arrangement is illustrated diagrammatically in Fig. 1, showing the cell construction, the circuitry for switching sensitivity ranges, a motor drive (1 cycle per minute) commutating switch to effect practically simultaneous plotting of both temperature and thermal conductivity curves, together with time rate indication. The conventional –200 C to 100 C temperature scale, and two calibrated thermal conductivity reference scales, plus two expanded off-scale ranges are also shown in Fig. 1. It will be interesting to note the relative positions of the usual components analyzed on the thermal conductivity scales, versus more customary temperature scale. The location of the cell in the complete analytical apparatus is shown in Fig. 4, ahead of the distillate rate and shut-off valves, by-passing completely all reflux liquid holdup, and most of the "pipe line" vapor holdup—thus annihiplishing the major objective of annihilating Analytical Enemy Number 1.

The actual performance of the "Thermocon," a name conveniently

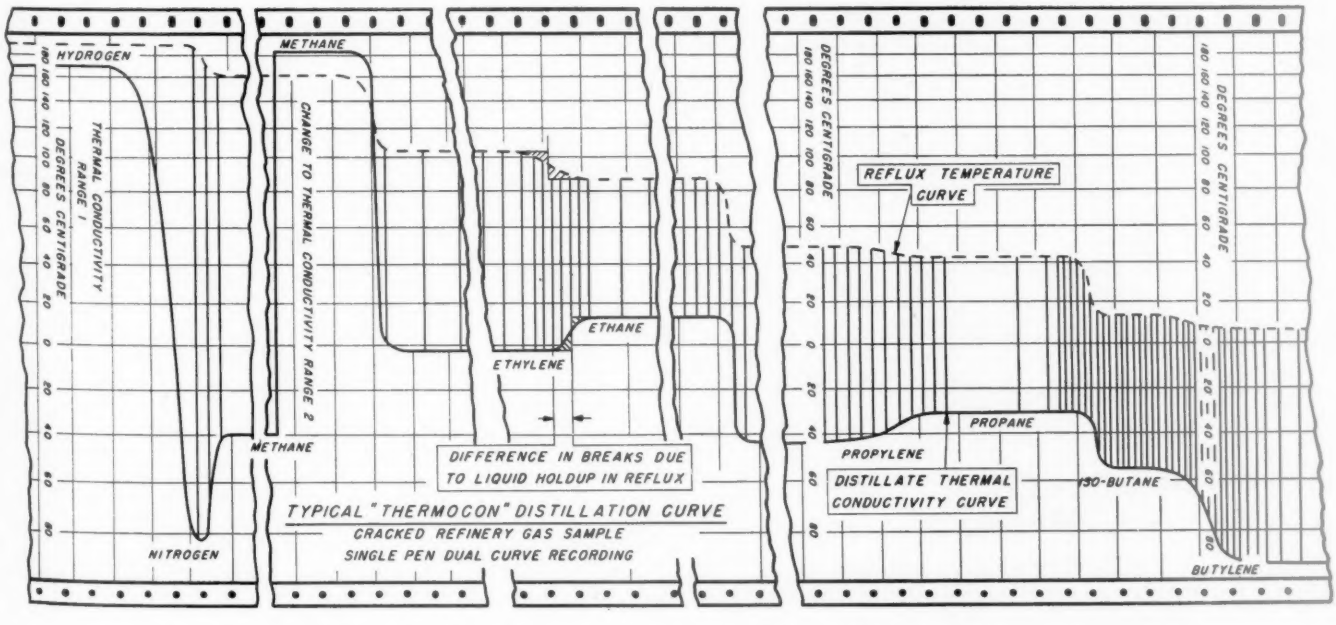
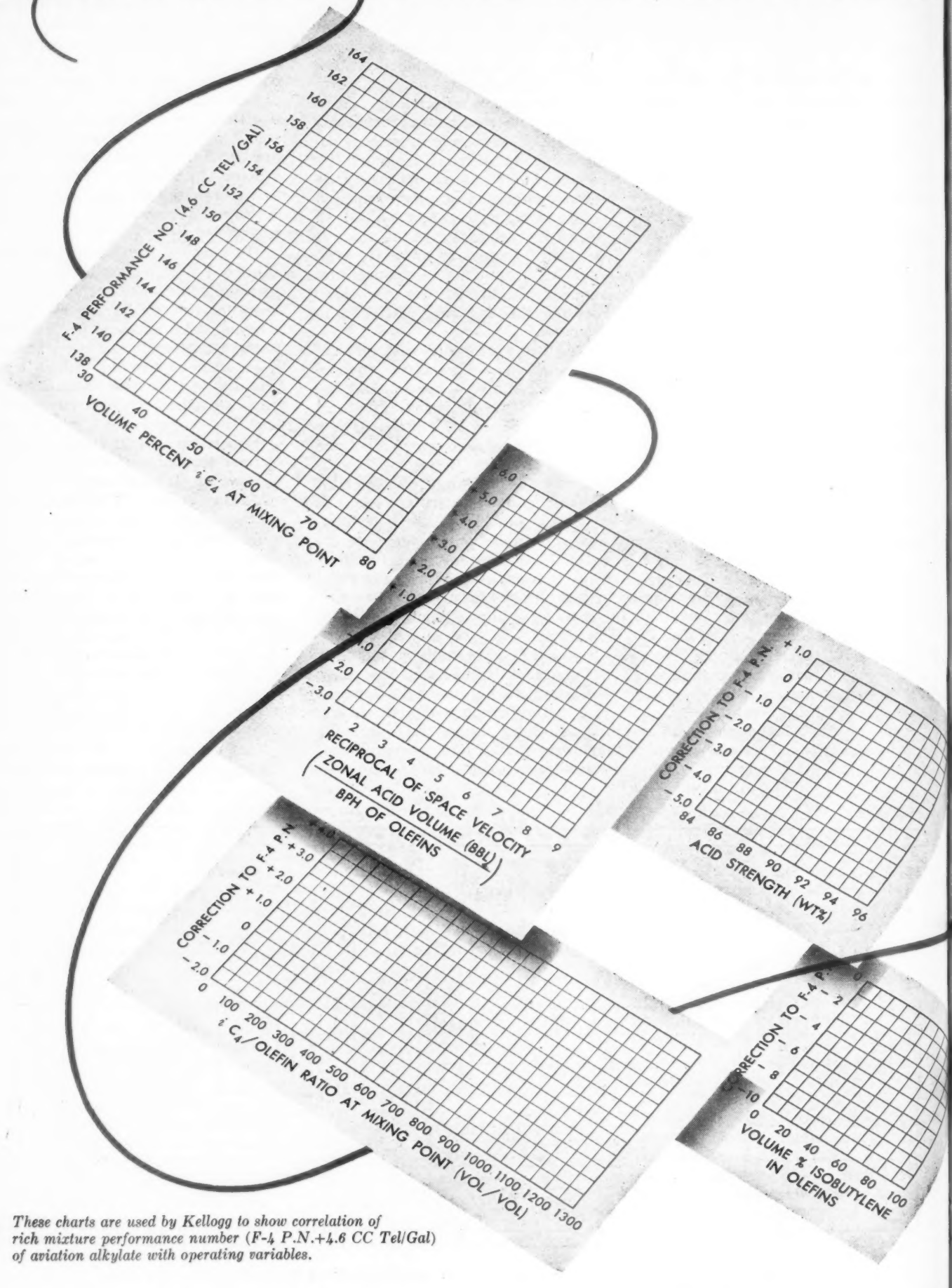


FIG. 2. Typical distillation curve of cracked refinery gas sample—single-pen, dual curve recording

INSIDE TRACK IN THE OCTANE RACE...



These charts are used by Kellogg to show correlation of rich mixture performance number (F-4 P.N.+4.6 CC Tel/Gal) of aviation alkylate with operating variables.

Kellogg Alkylation

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The accompanying co-ordinates demonstrate a few of the variables confronting the alkylate process engineer. The curves of these co-ordinates have been worked out through Kellogg research and experience, and the design results are available to refiners planning new alkylate capacity.

An example of what Kellogg alkylation can do in attaining premium results working with various blending components is provided by a recent study undertaken by Kellogg engineers of a proposed new 25,000 BPSD refinery on the Gulf Coast. Here, alkylation of total C_3 and C_4 olefins, assuming extraneous isobutane available at nominal price, results in the production of 15 volume percent on crude of high octane alkylate, with a payout on incremental investment over a base case of well under one year.

A comparable study of incremental alkylation not requiring extraneous isobutane, but compared with a base case incorporating non-selective catalytic polymerization, shows a payout of just over a year. Under these conditions alkylate production amounts to 6 volume percent on crude, and the combined alkylate plus catalytic polymer to slightly over 9 volume percent.

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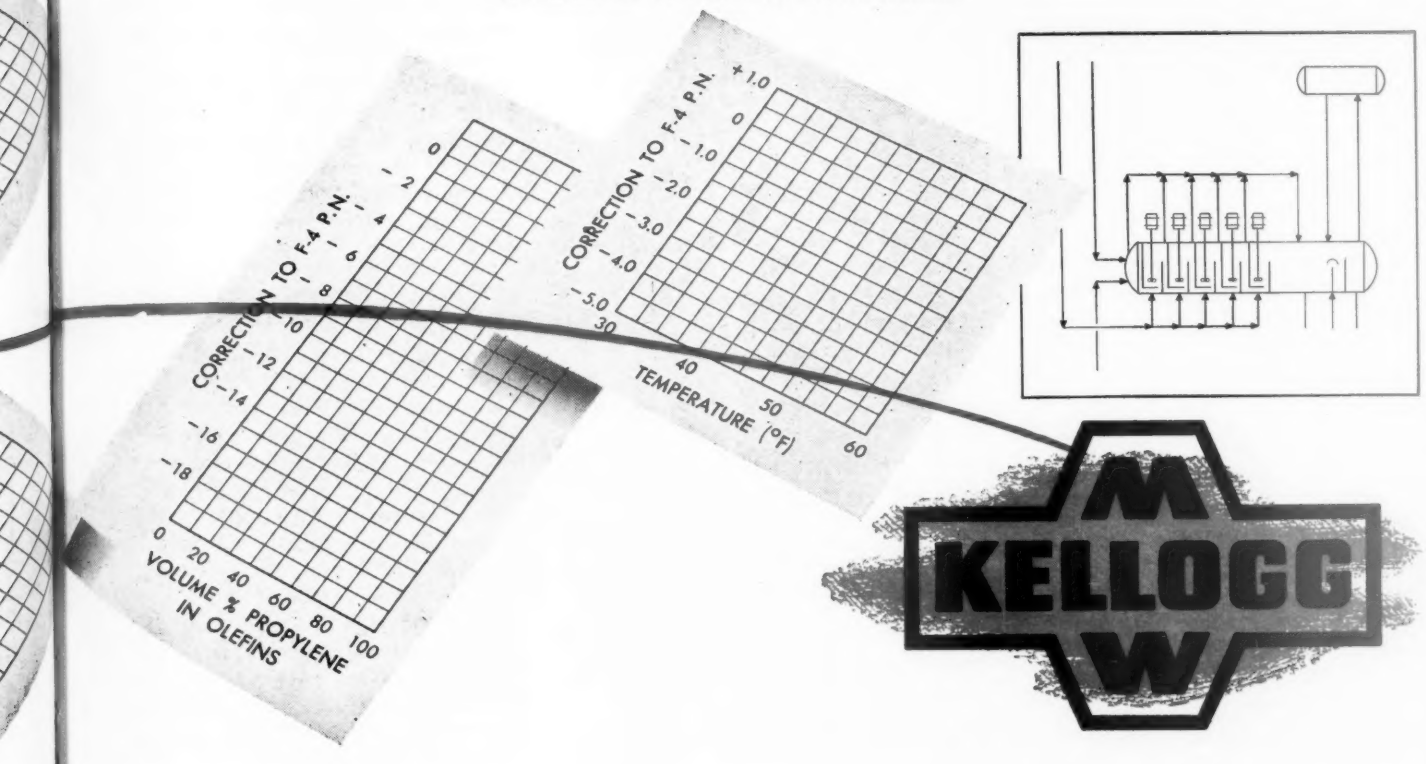

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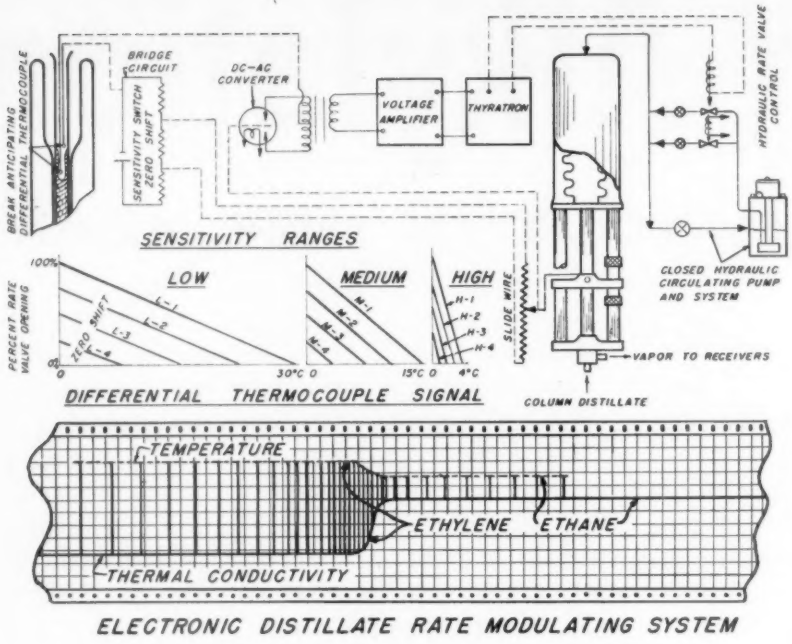

FIG. 3. Electronic distillate rate modulating system

coined to designate the thermal conductivity cell (circuitry, scales and associated components, is illustrated in Fig. 2, representing an actual distillation record of a cracked refinery gas as faithfully as compatible with reproduction requirements. Most interestingly, *hydrogen* and *nitrogen* are positively distinguished, evidencing substantial separation under actual column conditions. *Ethylene* from *ethane* and *propylent* from *propane* are distinguished more positively, and more correctly by thermal conductivity than by temperature. The difference in break location between the thermal conductivity and the temperature curves, as illustrated in Fig. 2 between ethylene and ethane discloses plainly the effect of reflux liquid holdup on the usual temperature curve.

As developed, the Thermocon has other valuable features besides inherent freedom from all liquid and most vapor holdup effects. The thermal conductivity of gas mixtures is practically a linear function of composition, and thus permits more accurate location of exact cutpoints, based on equal area determination, than the non-linear temperature composition relationships. Gratifyingly, the thermal conductivity of the gases hydrogen and methane to propane, inclusive, is practically constant from 200 to 800 mm of mercury, unlike boiling point. The vapor holdup correction for cutpoint location in thermal conductivity curves is about 5 cc thus making possible accurate analyses of gas samples as small as 100 cc, as will be explained later. The feature of dual recording of both properties is found to be invaluable in actual use, as a positive two-property check on each component, as a check on actual column operation, and in the case of new components, for which thermal conductivity data are not yet available.

One of the first uses of the prototype thermal conductivity cell was to evaluate completely, for the first time, the usual range of variation of reflux liquid holdup above thermocouple, with the interesting finding, among others, that this holdup was greatest for compounds of least boiling point difference, as isobutane and n-butane.

A priori, with elimination of holdups, linearity, etc., it would be expected that the use of the Thermocon would improve the general accuracy of LTFDA. The results of more than 100 distillation analyses on Phillips and other synthetic gas samples of known composition, as illustrated in the series of runs in Table 1, do show a very substantial reduction in residual errors on component percentages from the true composition. This could also be verified positively by comparing the indications of the temperature versus the thermal conductivity curve on each chart. It can be observed, that when the column is operated improperly, with "fat" reflux, or not brought to thermal

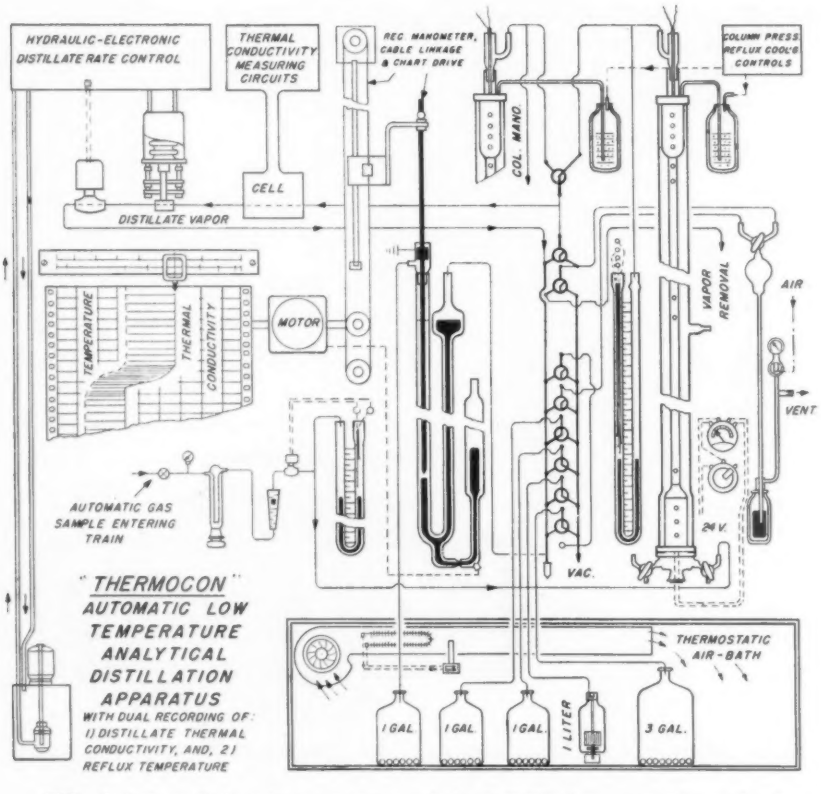

FIG. 4. Automatic low temperature analytical distillation apparatus—Dual recording of distillate thermal conductivity and of reflux temperature

TABLE 1. Thermocon analyses on samples of known composition

Phillips Mixture No. 32	Mol % Run #1	Mol % Run #2	Mol % Synthesis
C_3	2.41	2.61	2.62
iC_4	23.85	23.60	24.04
nC_4	73.73	73.79	73.34
Average deviation	0.26%	0.30%	
Phillips Mixture No. 39			
C_2	5.39	5.29	5.40
Propylene	15.52	15.44	15.85
C_3	74.90	75.15	74.55
iC_4+	4.19	4.12	4.20
Average deviation	0.18%	0.30%	—
N.G.A.A. Gas Sample No. 1			
N_2	13.23	13.00	12.99
C_1	74.78	75.01	75.03
C_2	6.38	6.38	6.31
C_3	3.75	3.75	3.67
iC_4	0.43	0.43	0.44
nC_4	0.93	0.93	1.00
iC_5+	0.50	0.50	0.55
Average deviation	0.109%	0.043%	—

* Statistically derived true composition.

equilibrium, or distillate rate is too high, that the temperature curve indicates incorrect percentages, probably due to heavy and variable reflux liquid holdup. The thermal conductivity curve, however, can be computed to accurate percentages.

With the successful elimination of reflux holdup error, it then became possible to evaluate other residual errors due to apparatus design.

1. *Distillate Measuring System* — The automatic distillate curve recording arrangement, as illustrated in Fig. 4 was checked by entering exactly known volumes of air and hydrocarbon gases into the system, to compare with the properly computed values derived from resulting chart travel. A small residual error was found, which was proved conclusively to be caused by sorption of gases in the stopcock lubricant. Considerable loss of material (10 to 20 gas cc) due to sorption was observed with hydrocarbon, rubber, and silicone base stopcock lubricants. The amount of material sorbed increases rapidly with an increase in the molecular weight of the gas in the system. As the result of considerable experimentation, a non-sorbing lubricant was developed which effectively eliminated errors due to sorption. Using the newly developed stopcock lubricant, the standard distillate recording system was found to be precise to within 1 to 2 gas cc.

2. *Separation in Column.*

(a) *Non-Condensables.* As already noted above, even hydrogen and helium, as well as nitrogen, are partially separable in the column, when using maximum liquid nitrogen cooling. However, it was not possible to measure the amount of this separation before, by temperature alone, without the determination of thermal conductivity of the distillate, as in Fig. 2. The analytical usefulness of the separation thus attainable is still to be evaluated by experience with the new apparatus.

(b) *Components Boiling> 20 C Apart.* It was most gratifying to note that with the use of the "Thermocon," methane from ethane, and ethane, propane and isobutane, as in LPG samples, can be separated by current design low-temperature fractionating columns[14] to within only 2 to 4 gas cc error on cutpoint estimation. It was now found possible, on LPG samples at least, to cut radically down sample sizes, to 200 cc vapor or less, thereby reducing analysis time to only about an hour, and still obtain consistent high accuracies as illustrated in the test data in Table 2.

(c) *Components Boiling 5 to 15 C Apart.* Ethylene from ethane, propylene from propane (Fig. 2), isobutane from n-butane, and isopentane from n-pentane are distinguished more sharply by this cell than by temperature. It now appears that on such close boiling components, the thermocouple does not do justice to the separation actually obtained in the column, due perhaps to conduction and other effects, as well as to reflux liquid holdup error. Note the very great sensitivity of Thermocon on isobutane versus n-butane separation, as shown on expanded ranges No. 3 and 4 in Fig. 1.

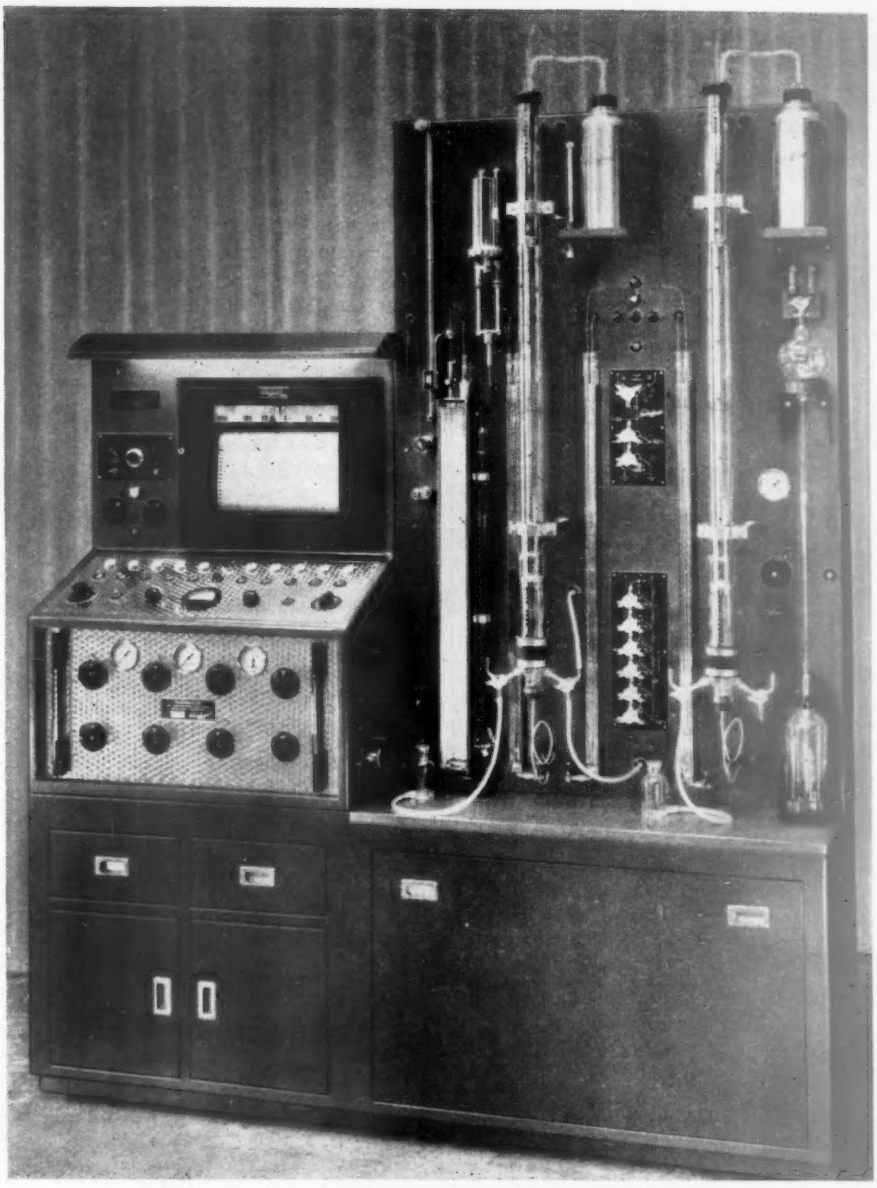

FIG. 5. View of Thermocon Unit assembled, ready for service

Automaticity and Speed Increased

An apparatus in good order, correct general analytical technique, and close continuous manual and/or automatic control of column pressure and distillate rate are prerequisite to attain the accuracies described above. Obviously accurate analyses cannot be expected with a leaking, dirty and otherwise poorly maintained apparatus, or with water in the sample, runaway distillate rates, etc. It was felt that there was room for considerable improvement, however, in automatic variable distillate rate control, to 1) extend automatic control to close-boiling components, as isobutane versus n-butane and propylene versus propane, currently distilled at *constant* low (time consuming) rates, and 2) permit the substantial (100 to 300 per cent general increase of distillate rates throughout analysis, as shown possible by Starr et al,[19] and thereby corresponding reduction in analysis time, without significant loss in accuracy. The previously experienced difficulties at high distillate rates, of controlling reflux liquid holdup and of securing correct thermocouple indi-

cation, are not, of course, experienced with thermal conductivity recording.

In the current automatic LTFDA apparatus, the distillate rate valve tended constantly to open slowly with time and to close rapidly, when 1) column pressure dropped below preset lower limit, or 2) reflux temperature (single top thermocouple) rose 0.1 C or more. It had been appreciated that a differential thermocouple with junctions spaced two or three inches apart at top of column packing,[10] would anticipate the "break" much sooner, would be more sensitive, etc. Experiments by the authors and others, using such a differential thermocouple to effect on-and-off control of the standard distillate rate valve, were encouraging.

Accordingly, what turned out to be a very ambitious and frequently frustating development program was set up around the idea of electronic modulation of distillate rate valve opening, from the differential thermocouple signal. The simplified diagram, Fig. 3, shows the final "electronic brain" as it has been dubbed in the authors' laboratory. A high-gain, drift-free amplifier operates a solenoid valve in the hydraulic servo system, to close down distillate rate valve, when the differential couple sends a signal due to temperature difference. A suitable bridge circuit provides for three sensitivity ranges (to compensate for major changes in boiling point difference of components currently distilled) and an adjustment for electronically limiting upper valve travel, using the slide-wire and contact on the rate valve as illustrated. The maximum opening of the rate valve is controlled by zero suppression in the bridge circuit, and the degree of closing is *directly proportional* to the temperature difference existing at the differential couple. It is preferred to set the lower knurled nut limit on the rate valve to establish thus mechanically, a definite minimum low rate, as determined by experience.

When the upper two or three inches of column packing are wet with a single pure component, the differential thermocouple sends no signal, and the distillate rate valve opens to maximum setting, to expedite the distillation far beyond usual cautious practice. There is no danger, since as soon as the next higher boiling component contacts the lower junction of the differential thermocouple, the control immediately closes the distillate rate valve, modulating the amount of opening and thereby increasing the reflux ratio. Even on the separation of ethylene from ethane (Fig. 2) the high sensitivity 4 C total span range is amply adequate, to control the situation completely without analyst intervention.

In actual use, the electronic distillate rate control as described is so effective in meeting almost all analytical situations, that even with cracked gas samples, little of the analyst's time or even attention is required throughout the distillation proper. More important is the greatly increased *speed* of distillation, since the control is now driving the column to its very limit of separating rate, at all times, instead of following necessarily highly conservative maximum distillate rates, as has heretofore been necessary. The time saving varies greatly with type of sample, and with control adjustments, but experience to date indicates that distillation time can frequently be cut in half without any sacrifice of accuracy. Finally, since the analyst is now considerably relieved of the responsibility and burden of setting and checking maximum safe distillate rates throughout the distillation, to the extent the effect of the human element on the accuracy of the results, is minimized.

"Short-Cut" Methods

The thermal conductivity cell principle makes possible several effective short-cuts to analysis results, as follows:

1. *Small Samples.* With LPG and similar simple type hydrocarbon materials, samples as small as 100 cc to 200 cc may be charged in the column and analyzed in about an hour, with satisfactory accuracy, as evidenced in Table II.

TABLE 2. Thermocon analyses with 500 cc receiver

Sample size = 140 to 180 Ml of gas.
Distillation time, including charging, less than one horu on all test.

Propane-isobutane system

	Test No. 1	Test No. 2	Test No. 3
C_3 (synthesis)...	51.136%	50.040%	50.511%
C_3 (calculated)...	51.145%	49.937%	50.321%
Deviation.....	+0.009%	—0.103%	—0.190%

Isobutane-n butane system

	Test No. 1	Test No. 2	Test No. 3
iC_4 (synthesis)...	49.897%	38.508%	59.003%
iC_4 (calculated)...	49.906%	38.592%	58.695%
Deviation.....	+0.009%	+0.084%	—0.308%

Ethane-propane system

	Test No. 1
C_2 (synthesis).....	52.567%
C_2 (calculated).....	52.756%
Deviation.....	+0.189%

Methane-ethane system

	Test No. 1
C_1 (synthesis).....	50.270%
C_1 (calculated).....	50.238%
Deviation.....	—0.032%

2. *Use of High Distillate Rates.* Even on close-boiling components, as isobutane from n-butane, once the pure isobutane plateau is established, the distillate rate control is adjusted to rush through the break in very short time, even though this procedure considerably lengthens the sloping portions of the break. With the expanded ranges, 3 and 4, of thermal conductivity, which is closely linear with composition, it has been found possible, even on such "sloppy" breaks, to determine the cutpoint, by the equal area method, with surprisingly little error, considering the great time saving. This is a new and useful concept in LTFDA technique.

3. *Re-Analysis of Fractions by Thermal Conductivity.* This method has considerable potentiality both for short-cut use, and for checking purposes. Thermocon automatic recording apparatus as shown in the general diagram, Fig. 4, provides for a special one-liter magnetically stirred receiving bottle, and for suitable connections between this bottle, the thermal conductivity cell, and the Toepler pump. With this arrangement it is possible to withdraw any distillate fraction, as the entire mixed portion of the isobutane—n-butane break, into the one-liter receiver, recording volume on the chart in the usual way, mix the receiver contents magnetically for a minute, then pass the mixed vapor, using the Toepler pump, through the thermal conductivity cell until an equilibrium reading is obtained. For a binary mixture, using suitable calibration charts for standard pressures, it is possible thus to determine the composition of the break fraction, within 0.5 to 1.0 per cent, within about five minutes.

The use of this method to check accuracy of cut-points normally obtained, is obvious. Another use of it is for the analyst to abandon completely the attempt to get a well-defined break between two close-boiling components, and to gallop the distillation through with a sole objective of securing a binary fraction, to be resolved by thermal conductivity re-analysis only.

Redesigned Apparatus

It will readily be appreciated that the Thermocon, the "electronic brain" and the re-analysis arrangement described above represent quite a radical change in the instrumentation, connections and general layout of the basic automatic recording LTFDA apparatus known to the industry. It, therefore, became desirable to design a new model, as illustrated diagrammatically in Fig. 4 and in the photograph, Fig. 5.

The control panels in the new apparatus are completely revised to incorporate the new features, also to make possible simplified wiring, easier maintenance and operation. The apparatus table is now integral, and contains the thermostatic circulating air-type bath, a compact closed cycle circulating pump arrangement for the hydraulic control, and convenient drawers.

The special Brown Electronik recording potentiometer plots dual curves for both temperature and thermal conductivity with a suitable commutating switch, as illustrated in Fig. 1 in detail. A separate time-rate jog curve is not required as the vertical intervals be-

tween crossover lines on the curves are proportional to time rate.

The thermostatic air-bath makes possible the convenient use of different capacity receiving bottles, as has become necessary with the new devices and procedures. The selective stopcock manifold was divided and revised, also all the vapor connections, to make possible the handling of very high distillate rates without undue pressure drops, as well as gas samples as small as 100 cc without large errors due to excess holdup in lines. The receiving manometer was changed from 8.0 mm to only 3.0 mm bore, to make practical the elimination of the "compensating taper" and its use with bottles of various sizes without significant error or laborious calculations. The gas sample entering system was automatized, as illustrated.

It is believed by the authors that the apparatus and procedures reported in this paper, will be found to contribute substantially to the problem of improving industry-wide accuracy, as discussed at the beginning of this article, as well as to improve the utility and the economics of this method of analysis, through reduction of necessary analysis time and personnel manhours. The invaluable help of the large fraternity of users of LTFDA in submitting criticisms, suggestions and reports of their experience with the method, and the specific organized help of the NGAA, through its cooperative interlaboratory surveys, LTAT School, etc., in indicating most useful directions of apparatus improvement and development, are most gratefully appreciated by the authors and their associates.

*Podbielniak, Inc., Chicago, Illinois.

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References

1. Esso Standard Oil Company, "Analysis of Hydrocarbon Mixtures by Low Temperature Distillation—Podbielniak Method."
2. Humble Oil and Refining Company, "Analysis of Normally Gaseous Hydrocarbon Mixtures by Low Temperature Distillation —Podbielniak Method" (July 29, 1944).
3. Miller, A. J., "Progress Report on Low Temperature Fractional Analysis Project for Liquid Hydrocarbons," *Petroleum Refiner*, Reference Annual, 21, p. C-40-44 (July, 1949).
4. Miller, A. J., "N.G.A.A. Fractional Analysis Program," *Petroleum Engineer*, 24 No. 9, p. C-31-36 (August, 1952).
5. Natural Gasoline Association of America, "N.G.A.A. Recommended Procedure for Analysis of Saturated Hydrocarbon Gases by Low Temperature Fractional Distillation," (April, 1946).
6. Natural Gasoline Association of America, "Proceedings of the Seminar on Low Temperature Fractional Analysis of Liquid Hydrocarbon Mixtures" (March 15-16, 1951).
7. Training School for Natural Gasoline Plant Analysts, *Chemical Engineer News*, 30, p. 2093 (May 19, 1952).
8. Podbielniak, W. J., "Low Temperature Fractional Analysis of Liquids and Gases; Part 2, Fundamental or Operating Technique, Causes and Cures of Errors," *Petroleum Refiner* (April and May, 1951).
9. Podbielniak, W. J., "Analytical Distillation and its Application to the Petroleum Industry," TAC Report HcAC-6. American Petroleum Institute (May 12, 1944).
10. Podbielniak, W. J., Doyle, C. M., Marco, Carl and Turkal, Peter, "Recent Improvements in Mechanized Low-Temperature Analytical Distillation Apparatus."
11. Preston, S. T., "Progress Report on the NGAA School of Low Temperature Fractional Analysis," Proceedings of the Natural Gasoline Association of America 32nd Annual Convention, May, 1953, Houston, Texas.
12. Preston, S. T., "Correct Low Temperature Fractional Distillatoin Analysis for Vapor Holdup," *Petroleum Refiner*, 32, No. 4, April, 1953.
13. Preston, S. T., "Low Temperature Fractional Analysis, *Journal of Engineering & Industrial Research*, 11, No. 4 (Summer, 1952).
14. Preston, S. T. and Podbielniak, W. J., "Low Temperature Distillation," *Petroleum Refiner*, 33, No. 4, p. 132-34.
15. Rose, Arthur and Elizabeth, Chapter IV of DISTILLATION, "Distillation of Liquefied Gases and Low-Boiling Liquids," Interscience Publishers (1951).
16. Shell Development Company, "Low Temperature Fractional Distillation," Shell Method Series, 399/47G (1947).
17. Smith, D. E., "Auxiliary Techniques in Low Temperature Fractional Analysis.
18. Starr, C. E., Jr., and Lane, Trent, "Accuracy and Precision of Analysis of Light Hydrocarbon Mixtures," *Analytical Chemistry*, 21, p. 572 (1949).
19. Starr, C. E., Jr.; Anderson, J. S., and Davidson, V. M., "Laboratory Low Temperature Fractional Distillation," *Analytical Chemistry*, 21, No. 10, p. 1197-1200 (October, 1949).
20. Universal Oil Products Company, "Gasoline Content of Gas—Low Temperature Distillation" (1940).

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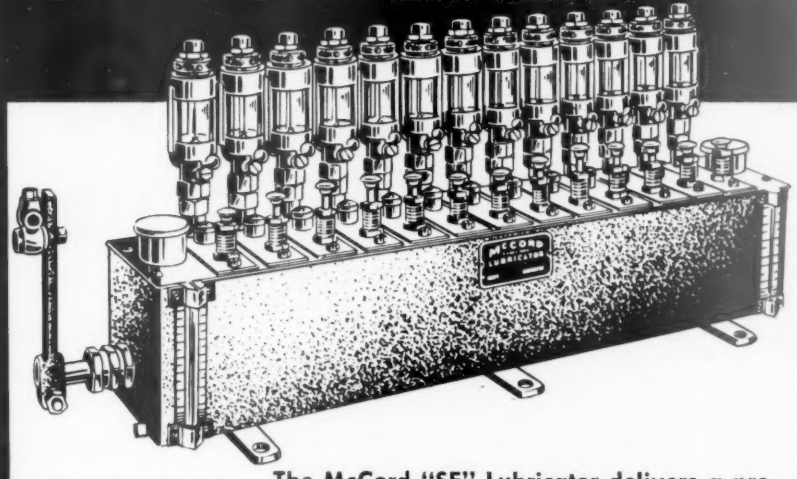

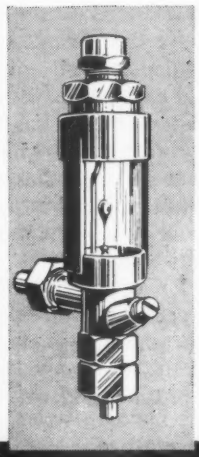

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Shop maintenance, repairs fire protection integrated with two-way radio communicatoin

FIG. 1. 900-acre Paulsboro, New Jersey refinery operates its jeeps, trucks, cranes via radio to cut labor costs.

FIG. 2. Chief dispatcher, Henry Cannavo, handles 250 messages a day, as he keeps tally on truck movements.

HOW RADIO HELPS REFINERY OPERATION

PAUL A. GREENMEYER*

SINCE 1609, when the first white man, Henry Hudson, sailed up the Delaware River, the site of the Paulsboro Refinery has been of great interest, both historically and industrially. During the Revolutionary War it was an anchor point for the famous Chavaux de Frise that protected Philadelphia from British warships. During the growth years of America it was farmland. Then, beginning in 1916, the Vacuum Oil Company purchased nearly 900 acres and erected the first units of the Paulsboro Refinery. Some of the petroleum industry's most revolutionary developments—such as fractionating and catalytic cracking units —were first erected at Paulsboro. Here, too, the most modern and the most effective communication ever developed finds extensive application. Socony-Vacuum Oil Company utilizes two-way radio communication to make efficient its materials handling, plant protection, and maintenance service operations.

The refinery is spread over 900 acres as far as the eye can see. It is completely independent of all municipal services; it takes care of its own electrical, gas, and water services, has its own fire-fighting protection, maintenance and sanitation. It has approximately 12 miles of railroad track and a trackmobile to move tank cars in the marshalling yard. Socony owns 2600 ft of dock and can handle as many as three tankers, one package ship and one lighter simultaneously. Petroleum products are shipped and received to and from all parts of the world.

Mobile Maintenance

Drivers roam over the refinery's entire 900-acre expanse with their trucks, trailers, and other special equipment—even to moving freight cars around on refinery tracks (Fig. 1). There may be a filling and grading job way down in the tank farm or a delivery of an air compressor or welding machine to a line under repair. All of these depend on the timely arrival of the refinery's mobile maintenance equipment which is hauled by truck or fork lift.

In an area the size of Paulsboro, mobility is important. In many cases, the equipment goes to the job rather than the old method of bringing the repair job into the shop. Repairs are thus speeded up and maintenance, always a big job in a refinery, is more efficient.

Keeping track of all the equipment and trucks as they spread out over the refinery, some of it constantly moving, is a big job. Calls are continually coming in on the dispatcher's phone asking for something to be picked up, brought, moved, or hauled away. Knowing what truck or equipment is nearest to the job at the moment is quite a trick.

The trick is two-way radio. The dispatcher can keep in constant touch with truck drivers all over the area, passing on and receiving information. Without two-radio, the automotive group would completely bog down. It's the big an-

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EXCLUSIVE

swer to operating a fleet of trucks on a hundred different jobs (Fig. 2).

Socony Radio System

One base station and 15 mobile radio units are employed. The base station employs a 100-watt FCA "Carfone" transmitter which is located in the garage of the automobile pool. Immediately adjacent is an 80-ft tower, supporting an RCA ground-plane antenna (Fig. 3).

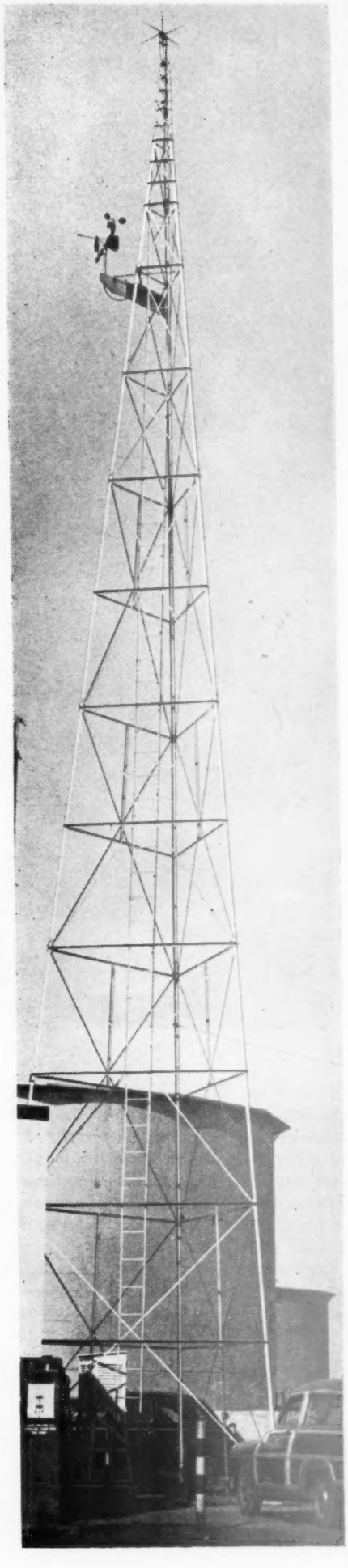
Mobile radio equipment is installed in 5 load luggers, 3 pickups, 1 plant protection vehicle, 3 stake trucks, 1 jeep, 1 fork lift, 1 winch truck, and a station wagon. The mobile radio transmitter and receiver are contained in a 16-gage steel case, approximately 15 by 20 by 5 in. They are usually installed underneath the driver's seat, in trucks, but in some cases are mounted inside weatherproof metal boxes atop the cab (Fig. 4). Controls, loudspeaker, and microphone are mounted on the dash within easy reach of the driver. This mobile radio is powered by the regular truck (or car) battery.

The base station equipment consists of transmitter, receiver, power supply, and controls. One set of controls is mounted on the dispatcher's desk at the automotive pool. By this means he can communicate with all radio-equipped vehicles. Another set of controls (remote controls) is installed at guard headquarters. Thus, the radio system can be operated from either point. Both can use the system alternately, or either can assume complete control. The base station equipment is powered by regular commercial 110 v a-c supply.

The radio system provides a coverage of 20 miles in all directions from the main station. It permits two-way communication—from truck to dispatch and vice versa—over this range. This amounts to a coverage of over 1000 square miles, not only blanketing the entire refinery area but also most of the surrounding metropolitan area. This is desirable because each day at least one truck makes a trip outside the plant for pickup and delivery in the surrounding vicinity.

The system operates on a frequency of 153.05 mc by authority of the Federal Communications Commission. Several frequency bands are reserved by the FCC for use of petroleum groups. Applications for licenses are handled through the National Radio Frequency Coordinating Association, which assists the FCC in its tremendous task by making recommendations for assignments. These are made in a manner so as not to cause interference. Men on these committees serve gratuitously. The API cooperates in this activity through its Central Radio Committee. Because the petroleum industry constitutes a vital service to the American economy, its standard of living and its defense, there is this recognition given by the FCC in allocating to it portions of the radio spectrum.

FIG. 3. 80-foot tower at motor pool station supports 100-watt RCA ground-plane antenna; Carone transmitter communicates with the 15 mobile radio units within 20-mile radius.



A duplex, one-frequency system is employed. Duplex means that two-way communication is possible—the dispatcher can both talk to and receive from each driver. (In addition, drivers can talk back and forth to each other.) Single frequency means that the system works like a party line telephone; that is, everyone hears every message. By this means all are informed of the status of operation, and anyone can volunteer information or help when he is in position to do so—even though he may not be the individual originally addressed. Thus, the complex and widespread enterprise is compacted and made smooth-running.

Each vehicle is assigned a number and is addressed by and uses that number in replying. This dispatcher uses the station call assigned by the FCC which in this case is KEA285.

Shop Operations Require Fewer Trucks

Before radio each shop had its own trucks. The pipe shop, electric shop, paint shop, boiler shop, etc., each kept at least one truck tied up—whether it was being used or not. Now, all trucks are kept at a central automotive pool and are used by the various shops as the need arises. A radio dispatcher in the automotive headquarters controls all truck movements. In this way fewer trucks are required and none are sitting idly by.

As soon as a driver finishes one assignment, he is given another via radio. For example, after he has taken a steam pump from the boiler shop to a job, he reports completion of the assignment to the dispatcher. He is told to proceed to another point, pick up welders and move them to a designated spot. By this means efficient use is made of all pickup trucks on the grounds. Drivers do not have to drive back to the garage or shop after each assignment but can proceed on to the next. Thus, radio saves considerable driver time and truck operating costs.

Speeds Repairs, Cuts Downtime

Mechanics can be reached faster by radio communication than was possible

FIG. 4. Weather-proof housing atop cab contains transmitter and receiver. Loudspeaker on hood can call someone several hundred feet away or can be used as P. A.

FIG. 5. Main gates are tied to Security Patrol and Plant Protection for quick, simple check on strangers, fires.

heretofore. Radio vehicles are constantly moving throughout the 900-acre grounds and one call from the dispatcher alerts all to be on the lookout for any desired personnel. Spare parts and equipment can also be moved more rapidly to the job by radio. Hence, the whole maintenance operation is made more efficient. This is especially helpful when emergencies arise and every second counts. In such a case radio can save vital equipment and protect the lives of everyone.

Radio equipment becomes especially important when process units go off stream. The radio serves the vital function of relaying calls for special equipment and supplies, for detailing men, and for coordinationg the whole project. It helps decrease shutdown time substantially.

Expedites Outplant Movements

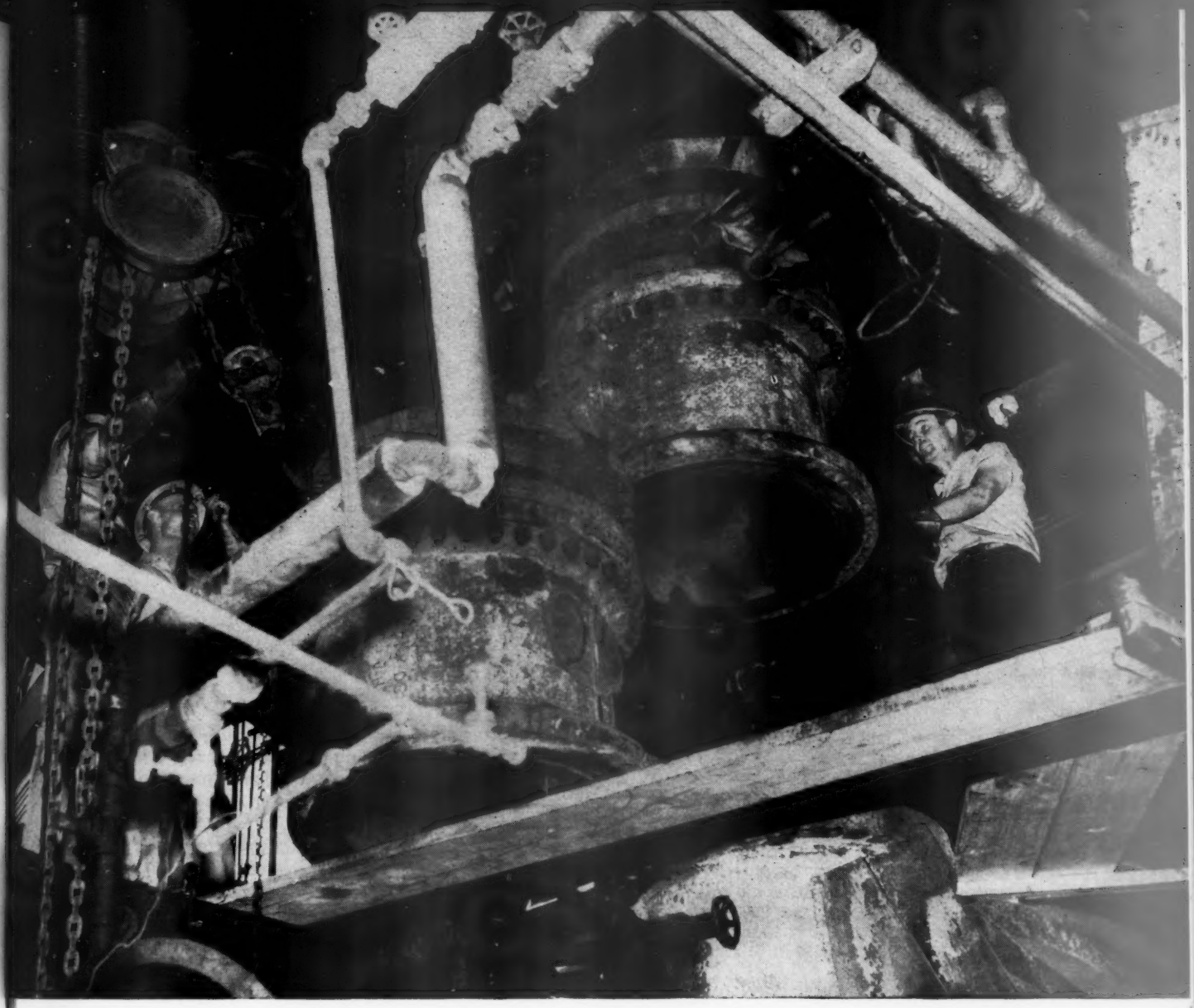
For emergency pickup of material from suppliers in the area a daily truck makes the rounds of the surrounding metropolitan area as far as 40 miles away. Should a need arise for an additional pickup after the truck has left, it is easy to reach the driver by radio. He is given the additional call and as a result the material arrives on schedule. Also, if the driver runs into a situation that requires a call to the office, he does not have to park and look for a telephone. He has immediate two-way contact right from his truck. By this means of instant communication, extra trips have been saved by radio.

Radio Load-Luggers More Efficient

These vehicles have been employed with a large amount of success in replacing dump trucks, since they can be constantly at work whereas dump trucks would be tied down for hours at a time. Load luggers are used to move large metal "pans" by means of a hooking and lifting arrangement, so that in practice they deposit an empty pan at a job and do not return until the pan is filled and ready for moving. Since the trucks are radio-equipped they can be busy transferring other pans, and fewer trucks are required to haul the plant load. Before this efficient operation was developed, dump trucks were parked at the job and did not move until they were filled.

More Effective Materials Handling

Stake trucks are generally used for moving drums, cases, pumps, and other general items as required in a refinery



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During the first quarter of this year, seven petroleum refineries have entrusted Procon with their turnaround projects, knowing that their on-stream operations would be resumed after just a short period of down-time. With the rapid completion of this important preventive maintenance work, these refiners were assured of continuous trouble-free operations in the production of high-quality petroleum products.

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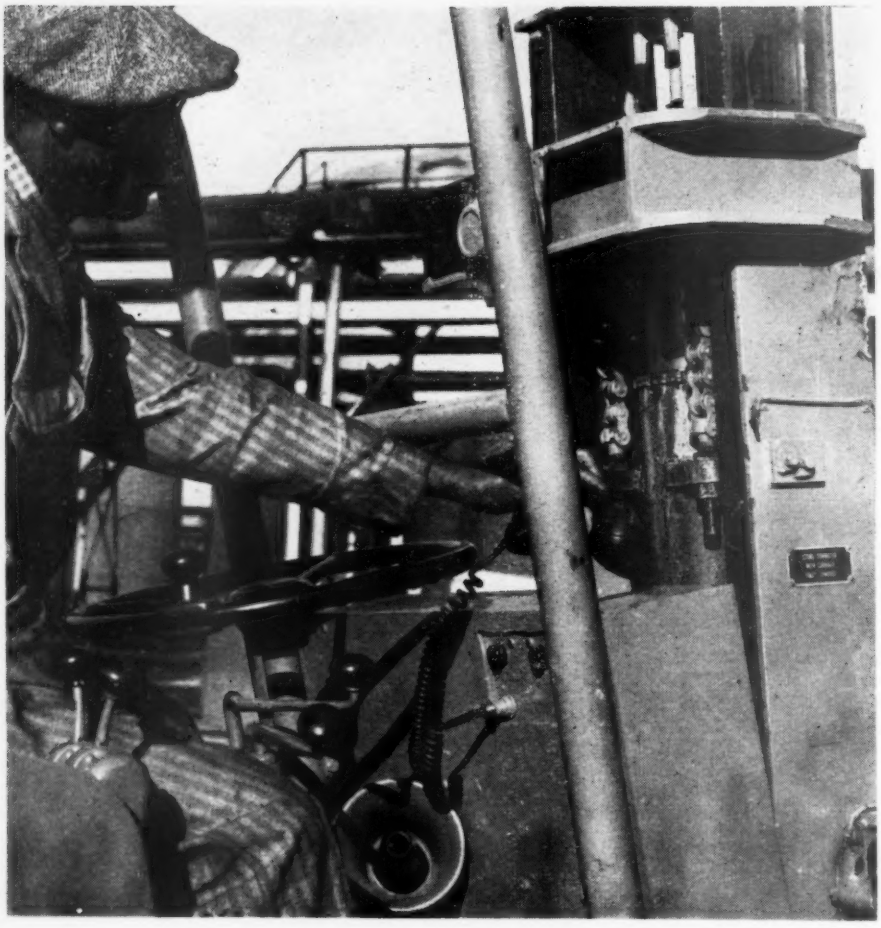

▲ FIG. 6. Radio handset is within easy reach of driver. Special loudspeaker resting against radio housing overrides background noise and is used for paging.

operation. For example, a typical movement would be to the tool room for pickup of a pump in order to empty a pool. After the job was done the stake truck would report back to the garage. With radio it can be moved directly to the next job.

Some 60 fork lift trucks are used to transfer and load drums at the export wharf. One of these is equipped with radio so that it can be employed for general work requiring a fork lift at any point on the grounds.

Eight or nine gangs of riggers are kept occupied at this busy refinery at the various assembly and disassembly operations needed in order to keep operations at peak efficiency by using latest techniques. A winch truck which is frequently used by these riggers is radio-equipped so that it can be rapidly dispatched to the place where it's needed. The fork lift is also frequently dispatched to lift up things for assembly. The winch is sometimes called for by electricians for pulling underground cable through a conduit. All these various operations are kept moving without waste of time by central coordination made possible by radio.

Helps Plant Protection

Safety and fire engineers are constantly patrolling the grounds in performance of their duties, checking and eliminating hazardous possibilities. In their station wagon they have two-way communication with their headquarters. This same vehicle is used by the night superintendent (Fig. 5). Thus in the event of emergency, no time is lost in getting into action. Also, routine matters are accomplished with fewer motions, since matters requiring attention can be handled directly from the vehicle.

Guard headquarters and one pickup truck used by guards are also equipped with radio. Visitors or suspicious events and characters can be checked on and followed up immediately from the scene of interception. During the night, when the regular radio dispatch room is closed down, guard headquarters acts as master control for the entire radio system.

Fire Protection

Fire fighting is of course a vitally important service at a refinery, and many of the personnel are trained in one or another phase of it and in administering first aid. Regular drills and training sessions are conducted to make sure that should an emergency occur, those who are selected are qualified to fulfill one part of this disaster work Radio plays a vital role in coordinating movements of men and material, asking for more aid, or calling for special foam and fire fighting equipment. It is used on the scene to contact and coordinate the entire operation. The radio car parks at the scene of the fire and takes over as control point.

Promotes All-Around Efficiency

The radio system started with eight mobile units and paid off so well in terms of efficiency that an additional seven were soon added. Some of the "extras" afforded by radio constitute aid to efficient operation. A driver, for example, after leaving the garage finds that he has forgotten certain tools. He does not have to turn back if he has radio, but can make arrangements for the next truck to bring them along (Fig. 6).

One pickup truck that is used to carry pipe and construction material is equipped with a special outdoor loudspeaker, which is practically a paging system in itself. When the driver leaves his truck, he switches the overhead loudspeaker into operation, and any calls received from headquarters can be heard for several hundred feet so that the dispatcher can get him at all times. Likewise, the unit can be used as an improvised loudspeaker system when the need arises.

In another instance, a certain plant official is urgently needed for a conference call, but while he is somewhere on the grounds, he cannot be immediately located. With radio, it has usually been found that by giving a general call on the system, the particular individual is spotted in short order. Furthermore, from any place in the refinery, officials can handle phone calls via radio contact with their offices when essential. Thus, the radio dispatch room becomes the hub of a communication center for the entire refinery.

Installation and Service

Socony's radio system was designed and installed by Raymond Rosen Engineering Products using RCA "Carfone" equipment. The equipment is serviced and maintained by the company's own instrument group. Under FCC regulations tuning must be checked every six months, using approved test equipment by licensed technicians, in order to make sure each user keeps to his assigned frequency channel. This is to insure that interference will not be caused to other systems. *

DU PONT DULUX Tank White had been protecting these "blimps" for 60 months when this photograph was taken. Yet there was no evidence of film failure or loss of reflective value despite a constant acid-fume condition in the area.

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New officers of the Western Petroleum Refiners Association; left to right are J. W. Vaiden, Skelly Oil; F. L. Martin Suntide Refining, reelected vice presidents; Bruce K. Brown, Pan-Am Southern, vice president; Reid Brazell, Leonard Refineries, president, and H. L. Kennedy, Continental Oil, reelected vice president. Brazell succeeds Roland V. Rodman, Anderson Prichard.

WPRA meet

P 700.

Atomic Energy Will Not Oust Petroleum

Paul D. Williams was elected executive secretary-treasurer of the Association.

"So far as we can see," says Walker L. Cisler, Detroit Edison Company president, "it (atomic energy) will never be a thing that is easy to handle and use . . . It can never supplant many of our present fuel requirements." Cisler told these things to the Western Petroleum Refiners Association at San Antonio, Texas, March 28-30. Furthermore, he said that the uses of petroleum and natural gas for purposes other than electric power generation will continue to increase and that ultimately we must supplement our natural hydrocarbon supplies with the synthetic product. By implication he indicated that although synthetics cannot compete now, a "comparatively small change in costs could alter the situation materially."

A 200-hp atomic automobile engine must have 60,000 lb—30 tons—of shielding to protect all concerned from dangerous radiation. Breeder reactors can be built to generate 100,000,000 watts of electrical energy. Reactors might cost $45,000,000 plus the cost of the turbo-generator unit, a cost greater than the value of all products, steam and plutonium. The breeder reactor makes more fissionable material as it produces energy.

World reserves of coal, oil, and gas total some 80 by 10^{18} Btu, it is estimated, whereas, the 26,000,000 tons of uranium and thorium known to be obtainable can produce 23 times that amount of energy, or 1800 by 10^{18} Btu.

Gas Turbine Car Engines

It is not yet clear to the researchers whether the gas turbine will replace the spark-ignition — gasoline — engine as power for automotive equipment, says W. A. Turunen of General Motors Research Corporation's gas turbine department. That department has built the XP-21 Firebird, first gas-turbine powered automobile in the United States, and the GM Turbocruiser, first turbine-powered bus in the world, for research and experimental work. Research must look toward fuel economy, and reduction of acceleration time. One big factor favoring the turbine is the power-weight ratio, the Firebird engine weighing 775 lb, or about 2 lb per hp; a diesel of equal power will weigh about three times as much, or, say, 2200 to 2300 lb. Commercially available premium motor oils appear equal to lubricating the jet-lubricated high-speed bearings, which are never exposed to the combustion area or to combustion products. The problems of power plants must be re-evaluated continuously in the light of new developments, Turunen said.

Additives Big Factor

Additive manufacture is already big business; changes in power plant design will alter the direction of research but not eliminate need for it, S. H. McAllister of Shell Development Company told refiners. That company having the best "know-how" as to manufacture and utilization of additives will have the best chance at leading the product quality race, he indicated.

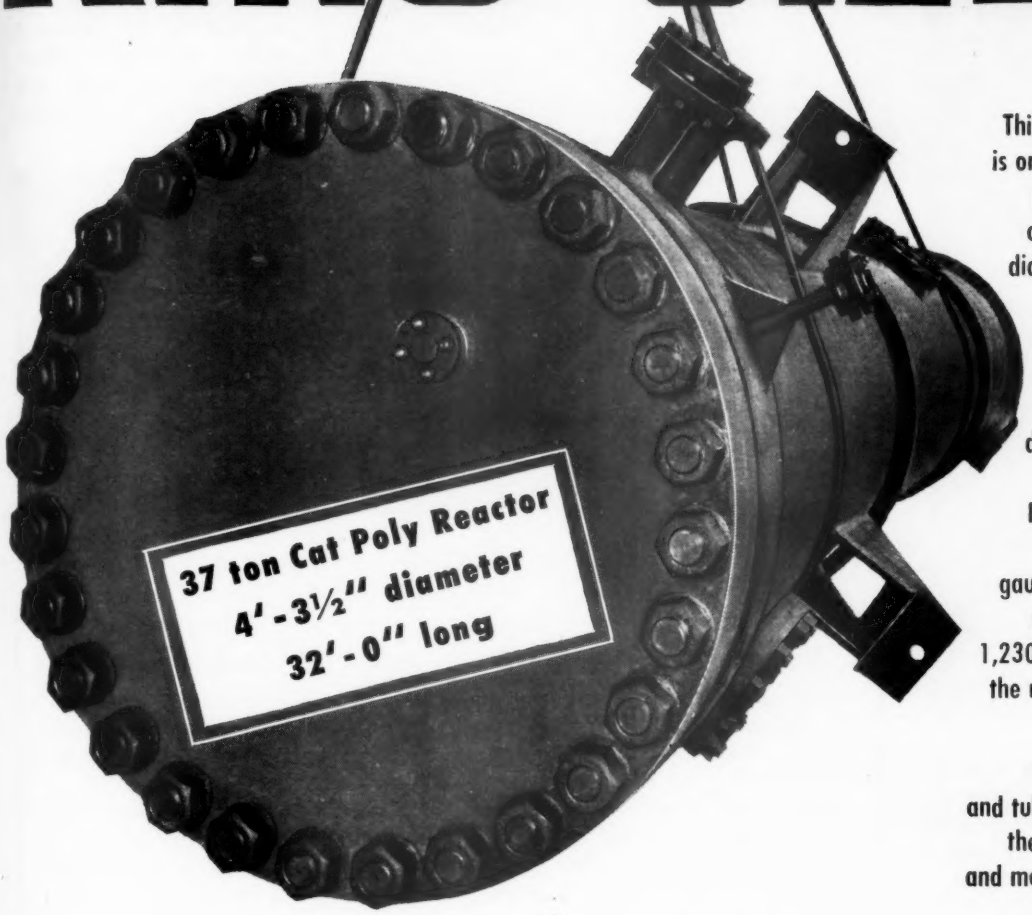
Outstanding in the additive field is the consumption of lubricating oil detergent additives; more than 250,000,000 lb were used in 1953, costing more than $50,000,000. The demands of wartime vehicles, especially diesel and heavy-duty equipment, and the use of detergents have improved greatly the performance of lubricants. As compression ratios of automotive engines are raised along with octane ratings of fuels, greater attention must be paid to the prevention or minimization of deposits in the combustion chambers of the 10-1 or 12-1 compression ratio power plants. Thus additives must be used more and more to strengthen natural lubricants, keep engines clean.

Advances in Catalyst Manufacture

Improvements in catalyst efficiency and properties have been under intense study for years. Recent reseach by American Cyanamid Company on high alumina fluid cracking catalysts indicates that these new catalysts have enough advantage over older type catalysts to warrant their use in this operation. The new material has about 25 per cent alumina, Al_2O_3, instead of 10, 15, 17 per cent as in older types. The greatest advantage is greater activity stability; the catalyst maintains its efficiency over longer periods under the same conditions. A given activity level can be maintained with less catalyst

A. M. Hughes, Phillips Petroleum, and Rex Winget, Cushing, Oklahoma, discuss industry problems and progress.

KING SIZE



This giant 37 ton Cat Poly Reactor is one of 4 units shipped to a large petroleum refinery in the State of Washington. It is 4'-3½" in diameter by 32'-0" long and has a 1 3/16" thick shell. Each of its 8" thick heads is attached to the shell channel with 28 special alloy stud bolts 2¾" diameter by 15¼" long having nuts 4¼" across the flats. Into the 5¾" thick tube sheets 190 tubes, 2½" O. D., No. 5 gauge and 30'-0" long, are rolled and seal welded. Designed for 1,230 lbs. pressure on the tube side, the reactor was completely X-rayed and stress relieved.

Vogt, a leading builder of shell and tube reactors for poly plants, has the competently skilled personnel and modern mechanical facilities with which to provide heat transfer equipment for the most exacting services in petroleum refineries, chemical plants, and related industries.

Reactors ... by Vogt

A bulletin describing the wide range of heat transfer equipment built by Vogt is available upon request.

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The Board of Directors of the Western Petroleum Refiners Association is shown at its first session following the election of the 43rd annual meeting, in San Antonio, Texas. Seated, left to right, are: F. W. McCurry, Walter Famariss, Jr., L. D. Mann, Bruce K. Brown, Don O'Hara, Roland V. Rodman, Paul D. Williams, Reid Brazell, Fayette B. Dow, H. T. Ashton, F. L. Martin, L. B. Simmons, J. W. Warner, and Rex S. Blazer. Standing, left to right: C. C. Tate, Dr. F. J. Sanders, T. E. Fitzgerald, R. L. Tollett, J. B. Smith, John S. Wertz, H. J. Kennedy, J. W. Vaiden, L. L. Leabo, Brown L. Meece, Everett Wells, J. P. Langfitt, Bruce McCully.

◀ George Brooner, Phillips Petroleum, and Shults Faulkner, Pona Engineers.

◀ Convention staff registers delegates.

▲ Charles J. Holland, Rado Refining; Harry Litwin, Century Refining, and T. F. Kreipe, Selas Corporation, talk on weighty matters.

make-up than formerly; also better selectivity can be obtained by lower operating temperatures said B. H. Loper of Cyanamid.

The 25 per cent alumina catalyst shows as good product distribution as does a 13 per cent alumina catalyst "as long as the alumina is in the properly combined form." Some stocks show better selectivity for the 25 per cent Al_2O_3 catalyst. Lower stack catalyst losses result from the higher alumina product. Metal contaminants removal can result from this, if a catalyst removal program is employed in the plant.

Octane Needs vs Sensitivity

There are indications that as octane requirements of engines increase, they rate fuels closed to Research octane ratings, says T. W. Warren, J. S. Wintringham, and C. R. Penninger of Ethyl Corporation. Design engineers on automotive engines will take full advantage of increases in octane ratings in the engines they work out. Greater knowledge of the properties of fuels must be obtained; it is recognized that fuels of a given sensitivity can behave differently either because of differences in hydrocarbon composition or because of the volatility effects that are found so readily in multi-cylinder engines.

Demand Rise, Foreign Crude Among Refiners' Problems

Increase in product demand, the specter of a "flood" of foreign crude greater than the domestic industry can handle, the headlong "octane race" and excessive refinery throughputs are among the more crucial problems facing the refining industry, judging from statements made by Roland V. Rodman, retiring president, Western Petroleum Refiners Association.

The keynote sounded by this leader may be considered to be: "Let us dedicate ourselves to the reduction of production, imports, and refinery runs to the end that we may all live in the same house." Some companies have carried the octane race beyond the general requirements of the American motorists, and have thus raised appreciably the cost of making gasoline, he said. Products demand forecasts indicate 8½ million barrels in 1955. Even though the number of refineries has dropped from 365 to 304 in the last four years, the total refinery capacity is now 8,639,000 daily barrels, with an additional 2,000,000 bbl under construction. Demand estimates show need for 9,760,000 bbl of products by 1960, and by 1975 we are expected to consume 13,700,000 bbl of petroleum daily, this last figure being that of the Paley report.

Residual fuel demands has failed to increase due to a 46 per cent drop in railroad consumption, 22 per cent in power plant needs, 10 per cent drop in bunker fuel demand. The industry is reducing heavy fuel production strenuously.

Foreign crude is pushing harder into the domestic market, he warned. Before World War II, East Coast refineries used 15 per cent foreign crude for their runs; last year 54 per cent of all crude in these plants was foreign. Too high percentage of the industry's total income is concentrated in too few hands. If not reversed, this trend could bring public utility control on us. As the octane level rises, the differential in cost of refining, between regular and premium gasoline becomes greater and greater; we must make the types of fuel needed by the motorist, but must evaluate the cost of these products and must establish values and differentials in the light of these facts, Rodman stated.

First of Three Articles

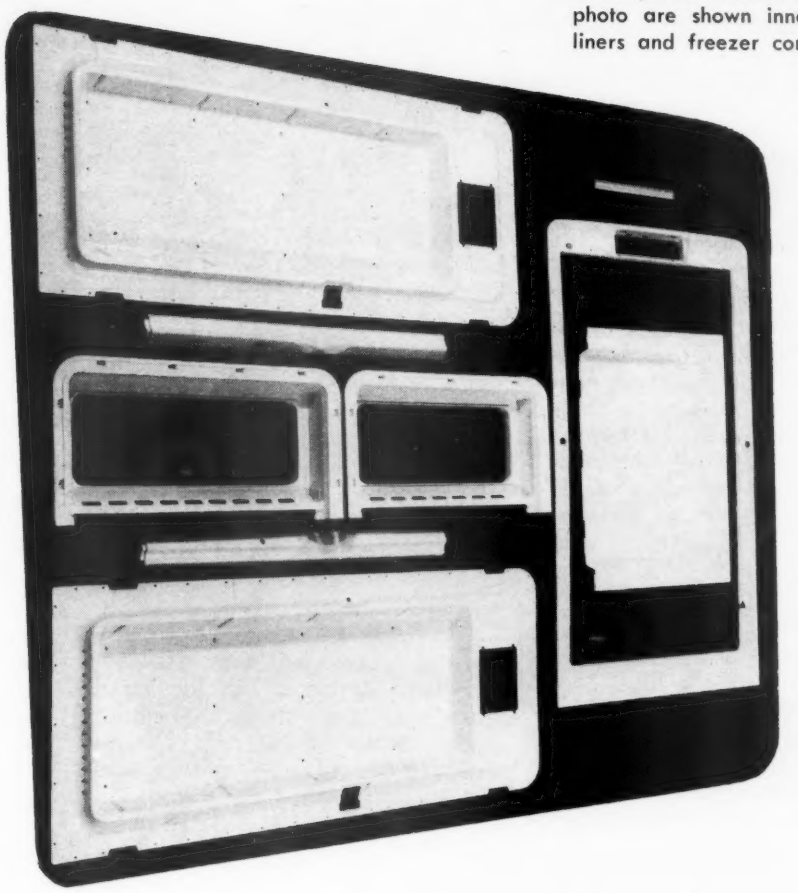

FIG. 1. Plastics are divided according to their end-use; tough, high-impact styrene makes up about 65 per cent of all plastic used in refrigerators; in photo are shown inner door panel, liners and freezer compartments

PLASTICS IN PERSPECTIVE

George Barsky

EXCLUSIVE

This is the first in a series of three articles explaining in detail one of the most variegated subjects in petrochemicals: Plastics. Dr. Barsky, a widely-known and eminent scientist in the field of plastics, starts his first article, "Plastics in Perspective," by rejecting as irrelevant the traditionally accepted definition of plastics along thermoplastic or thermosetting lines. More to the point, he writes, is the end-use as a selective factor.

In the second article appearing next month, Dr. Barsky will discuss, "Plastics on Parade," a detailed look into individual plastics, their sources of raw materials, their manner of manufacturing and fabrication, and their principal uses.

The third article, to appear in July, 1955, will consider "Plastics in Preview." He will attempt to estimate the near- and far-term prospects for plastics from the vantage point of practical considerations: Supply of resins to fabricators, prospects for manufacturing, techniques of fabrication and new uses.

THE plastics materials industry embraces a vastly diversified collection of products, a great variety of manufacturing operations, and almost all types of raw materials. The basic reason for such unusual diversity in one industry arises from the nature of the industry itself and from the functions that plastic materials play in modern industry generally.

Introduced many years ago, the term "plastics" referred at first to materials whose properties permitted their being shaped by heat and pressure, or by pressure alone. The ordinary connotation of the word plastic implies a soft and yielding material, but it also is commonly applied to many products not exhibiting plastic properties, such as finished, unyielding moldings and liquids set by reactions to castings or rigid form. Like the term "petrochemical," plastics has shifted far off its etymological meaning.

Definition

A new definition is required to explain many of the features of the pres-

ent industry and to permit more intelligent estimates of future prospects. For these reasons, the following definition is submitted: **Plastics are organic compositions synthesized for fabrication to structures or devices.** This definition limits plastics to organic compositions, entirely synthetic, or to natural materials modified by the methods of chemical synthesis, and groups these all together in terms of their common end-use (Fig. 1).

Chemical composition is of little importance as a differentiating mark of plastics. Whether a small gear contains adipic acid or phenol in combination is unimportant. Whether a radio cabinet can be reheated and reformed after fabrication is of no concern. In some fields, as in medicinals and pesticides, chemical properties of products is of vital importance as the utility of the product is accomplished by chemical action. But insofar as the use is concerned, the chemical properties of plastics are of minor importance. The important things are the structural properties which in turn depend on the configuration or the structure of the molecules and their association.

This definition of plastics indicates a departure from the course the chemical industry has perennially followed. The chemistry of plastics (or plastic material industry) is primarily directed to the *physical,* not the *chemical,* properties of the materials. As a result, technological emphasis has changed from the classical chemical science to newer branches of the physical sciences, such as the chemistry of polymerization, the behavior of macromolecules, rheology, etc.

The plastics industry has given birth to a new branch of the chemical industry: synthetic structural materials. As with all new phases of knowledge, be they radiation, the atom, transistors, this new branch also opens up great unknown vistas whose potentialities for growth are just now being realized. This new branch of the chemical industry promises to strain the manufacturing facilities of the industry and to create demands for raw materials totally unprecedented and almost beyond prediction.

And yet organic plastic materials are not new. The spectacular rise of synthetic materials may perhaps have obscured the fact that fairly large quanities of natural plastics materials (asphalt, rubber, resins, gums, etc.), known for centuries, are consumed every year. Natural plastics, however, have a limited set of characteristics that cannot be easily or economically changed—if they can be varied at all. With the extensive industrial development of the past half century, the demand for products has surpassed the available supply of natural raw materials. At the same time, the new markets require products with specific properties that cannot be supplied solely by the traditional raw materials. As chemistry has advanced in knowledge and industry in manufacturing ability, the indispensable tools for the technical development of synthetics became available.

The oldest synthetic plastic is nitrocellulose plasticized with camphor (Celluloid) developed by the Hyatt brothers in 1868. Then followed the casein plastics (1898) and cellulose acetate (1903). All these synthetics were modified natural products, their chemical modification being directed to increase ease of fabrication with available equipment and to improve physical properties. The first all-synthetic plastic, that is, one prepared from non-plastic, non-resinous raw materials by the synthetic methods of organic chemistry, appeared in 1909 with Baekeland's development of Bakelite. The unique properties of this material found a ready market, particularly in the electrical industry. Since then a succession of new plastic materials has followed.

The Author

George Barsky is a chemical engineer, graduate of Columbia University (PhD, 1922) where he served as research assistant in the department of chemistry and held the Bridgham Fellowship for engineering research. Joining the American Cyanamid Company in 1922, Dr. Barsky was appointed director of experimental laboratories in 1926, as well as acting chief technologist.

In 1933, he established his own chemical engineering consulting firm in New York where he has his laboratories and offices. His practice involves various branches of the chemical industry and plastics. During the war he served as Commander ASNR (Ret.) and was in charge of the electrical insulation section, and the mechanical, chemical and metallurgical divisions. Dr. Barsky holds more than 40 patents and is the author of numerous papers in the technical press.

Synthetic Rubbers and Fibers as Plastics

Synthetic rubbers conform to our definition of plastics (or plastic materials) as synthetics manufactured for fabrication to structures or devices. Synthetic rubbers are plastic materials in which the outstanding property is elasticity. Other properties, such as abrasion resistance, hardness, etc., may be adjusted by altering the original composition or by compounding and vulcanization. A number of plastic materials of chemical composition greatly differ from those of hydrocarbon rubbers and exhibiting elastomeric qualities, have been proposed for the same uses, some with remarkable superior qualities. Synthetic rubber is so large an industry that its close connection to the plastics industry has not been obvious. Variations of the common GRS rubber, for example, the high styrene-butadiene polymers, are used for other plastic purposes. Significantly, several of the major rubber companies are now producing vinyl and other plastics because the manufacturing, the fabrication and the uses of both plastics and rubbers are closely related.

Synthetic fibers also conform to our definition of plastic materials. In this case also special properties are required: The ability to form fibers and the properties required for the woven fabric. In some cases, for example cellulose acetate and nylon, the same materials are used for fiber and for other plastic outlets.

Growth of Plastics

Table I shows the production and the total value of the products of various branches of the organic chemical industry in 1941 and 1953. The dyestuff industry has increased slightly; medicinals have doubled in tonnage.

Plastic materials alone have increased about sixfold. The actual tonnage now exceeds by far any other branch of the organic chemical industry, as does the total dollar value, even if synthetic rubber is not included.

TABLE 1. United States Production of Finished Organic Chemical Products

	1953*		1941	
	Millions of lb	Unit sales value $ per lb	Millions of lb	Unit sales value $ per lb
Dyes	166	$1.10	169	$0.64
Medicinals	67	7.52	34	2.02
Pesticides	356	0.35	—	—
Surface active agents	922	0.20	—	—
Synthetic rubbers	1958	0.28	28	0.56
Plastic materials	2777	0.35	452	0.34

* The future will be discussed in the third paper of this series.

Chemical Basis of Physical Properties

Plastic materials are usually mixtures of related compounds of high molecular weight, termed macromolecules. Nature has provided many such materials that are used in their natural state, as is the case with natural resins. The macromolecules of nature may be modified by chemical reaction, as in

Du Pont's new polymeric additives help prevent engine sludge under low-duty driving conditions

Which

of these two new lube oil additives will do most to help sell your motor oil?

If you are looking for an outstanding sales theme to help expand your motor oil market, here are two entirely *new type* Du Pont lube oil additives that offer just such an opportunity.

Both are *polymeric* additives that provide an economical and effective means of preventing engine oil sludge . . . particularly under low-temperature, low-power, stop-and-go driving conditions. Both do double duty as detergents and V. I. improvers.

As such, they can add important sales appeal to your products in the mass passenger car field as well as in bakery and other urban fleet markets.

With either of them, in multigrade oil formulations, you supply not only superior low-duty detergency, but also *provide a substantial part* of the viscosity index improvement required.

Usually such formulations produce better performing oils at lower cost than can be obtained through other additives or methods.

DU PONT LUBE OIL ADDITIVE 564 is a new type polymeric additive which, because of its relatively low molecular weight, provides your oil with excellent shear stability in engine operation.

DU PONT LUBE OIL ADDITIVE 565 has a higher molecular weight than Lube Oil Additive 564 for greater viscosity index improvement.

Form no sludge

These ashless polymeric lube oil additives permit more efficient operation of the engine oil system. Oil screens, rings, pistons, filters and other engine parts are kept clean and free from sludge. The resulting free flow of oil throughout the entire engine system keeps it in better operating condition for longer periods of time.

Commercial quantities of both additives are now available. For testing their effectiveness in your own motor oils, any of our representatives or regional offices will be glad to supply you with samples.

TO HELP YOU MERCHANDISE your lube oils containing Du Pont Lube Oil Additive 564 or 565, this unique promotion kit is now available. It contains *suggested* copy and layout for newspaper ads, descriptive folders, a 24-sheet highway poster, an envelope stuffer, and suggested sales talks for your dealer meetings. Also, a 12-page technical book with all the basic details on these new additives.

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cellulose acetate or casein-formaldehyde, but only limited modifications can be introduced. The resulting plastic often retains some deficiencies associated with the original material. The limitations of natural materials are avoided by the use of a variety of low molecular weight units that can be combined to form truly synthetic macromolecules. In such a combination a succession of chemical reactions is required to build up to the high molecular weight that is characteristic of compositions with plastic properties. Since the choice of structural units is very large it is possible (as is evident from the variety of plastic materials on the market) to produce materials with numberless variations in properties, variations that do not occur with any natural material or modified natural material.

FIG. 2. Polyethylene resin, the fastest growing plastic, made into a flashlight cast, is waterproof, will not corrode, and is virtually indestructible

For example, vinyl chloride monomer, a gas at ordinary temperatures, combines with itself (polymerizes) to form polyvinyl chloride, the plastic material used for shower curtains, etc. By replacing some of the vinyl chloride by vinylidene chloride, or vinyl acetate, or maleic acid, the properties of the resulting plastic is modified. A rigid material, polystyrene is obtained by polymerizing vinyl benzene (styrene); yet vinyl benzene and butadiene mixtures are used to produce GRS, the most common of the synthetic rubbers.

The structure of the macromolecules of plastics may be long chains, or long chains with cross linkages, or more complicated configurations. Physical properties depend both on the structural units and the manner in which they are linked to one another. The analogy to mechanical structures is striking. For example, a helix type of structure is probably responsible for elasticity; cross linkages in many directions tend to give more rigid, brittle structures. Hydroxyl and amino groups promote poor water resistance. Long carbon chains impart hydrocarbon solubility. Ester groups in many instances give products subject to hydrolysis. Phenyl groups tend to decrease elasticity.

FIG. 3. Plastics do not generally compete with other materials; here the use of lightweight, rigid vinyl pipe saves manpower and time in installation

In order to permit a forming to shape, synthetic plastics must be able to exist in a liquid or semi-liquid condition prior to final forming. Some materials, polyethylene for example, merely on heating acquire enough plasticity for extrusion, injection molding, or blowing, and can be repeatedly softened and reformed. Such materials are called thermoplastics. Some may be poured into a mold as a liquid and polymerized to final shape; methyl methacrylate sheets, formed in this way, are thermoplastic and may be heated and shaped. Others, such as phenolic molding resins, while in the plastic state undergo further chemical reaction, such as polymerization or cross linking that results in a structure that is rigid even when hot. This type of material cannot be reprocessed although when hot it may be capable of some minor mechanical manipulation. Cross linkable materials are known as thermoreactives. They can withstand higher temperatures without distortion than thermoplastics; however, as the properties of the latter are now improved so that some are often interchangeable with thermosetting materials, the distinction between the two types of materials is of less importance.

Selecting a material for a particular job is no simple matter: It requires intimate knowledge of the properties of the material, the methods by which it can be fabricated, and detailed adjustment of the design of the final product to the properties and to the method of fabrication (Fig. 2).

The adaptability of the composition to the particular mechanical form and service of the finished product is critical. For example, one plastic material, a drying type alkyd resin, is particularly suitable for use as a protective coating on automobile bodies, but can be formed to a rigid structure only with difficulty. Another, a moldable phenolic resin, is unique in its excellence as a material for the ignition distributor head of gasoline engines and entirely unsuitable for use as a coating material. Nylon, in spite of its high price, has proved to be superior to other materials as a formed plastic subjected to friction and impact. At present there is no material that has the properties of polyethylene for wrapping of food. No other material in film form possesses polyethylene's moisture resistance and its oxygen and carbon diaxide permeability.

Position of Plastics In Industry

Synthetic plastics have two characteristics responsible for their very rapid growth: They offer combinations of properties not heretofore available to, but desired by, industry; and they fit into mass production methods. The advantages of plastic properties in mass production with other materials are not new; that steel can be rolled hot or cold is due to its plasticity. However, with organic materials the usable temperatures, though elevated, are seldom above those obtainable by the use of steam. It is possible, of course, for plastic materials to be developed for use with higher temperatures and more rapid forming. This would result in greater stability of the formed piece at elevated temperatures, often a very desirable property.

Just as there is no universal metal adaptable for all purposes, there is no universal plastic. As the number of plastic materials increases, the variety of properties available in the finished piece increases and the broad spectrum of uses expands. A similar expansion is taking place in the metal industry with the development of the newer metals such as titanium, zirconium, boron, berylium, etc.

As with metals there is usually a definite reason for the use of a particular plastic for a particular purpose. The cost of the finished piece may be below that of a similar article made from competitive materials; the par-

ticular plastic may have properties sufficiently superior to warrant a price differential over other materials; or its qualities may be so unique or in such indispensable combinaion that cost is not a deciding factor.

Plastics offer combinations of properties that cannot be obtained with metals, such as low heat conductivity, electrical resistivity, low coefficient of thermal expansion, and flexibility. Metals can be fabricated into simple shapes with at least equal cheapness but, except in the limited fields of die and investment casting, the precision production of complex forms requires expensive machining operations with metals. Plastics, on the other hand, can be molded cheaply to very intricate shapes. Metals and plastics complement one another and do not compete in any large tonnage outlet. During the last war, initial shortages resulted in the substitution of plastics for metals and, perhaps, was responsible for their misuse. For many years to come the common metals, such as iron and steel, probably will remain cheaper than plastics in simple forms and in large size, but many replacements of metal may be expected.

Methods of Fabrication and Their Importance

There are plastics that may be welded, sawed, sheared, stamped, rolled, drawn, cemented, embossed, molded, blown, etc. Of course, there are limitations to the variety of methods applicable to any one plastic. The original fabricating techniques are offshoots of those in use for other materials. For example, the heat and pressure molding of Bakelite is an adaptation of the vulcanizing technique of the rubber industry. Injection molding is really an outgrowth of die casting. The calendering of thin sheets was adapted from the rubber industry; the blowing of polyethylene from the glass industry.

Methods of fabrication have been adapted to the properties of the plastic materials themselves but plastic materials have also been changed to make them more suitable for particular methods of fabrication with the result that a process of action and reaction is continuously occurring in the industry.

The continuing development of fabricating methods is of great importance to the plastics industry and, perhaps, is not generally sufficiently recognized. Such developments have greatly increased consumption of plastic materials. Thus, new machines developed to mold large objects, such as radio cases, required definite changes in molding materials. Their successful modification led to increased consumption (Fig. 3).

The manufacture of large sheets of homogeneous floor covering of vinyl compositions similar to inlaid linoleum is delayed by the lack of a suitable combination of material and machine. At present the machines available cannot handle compositions that would be satisfactory in service, and the compositions that can be handled by the present machines are not suitable. When the problem is solved a very large market will be opened up. The development of gels containing vinyl resin particles dispersed in plasticizer and capable of maintaining a fixed shape even during the heat fusion of the resin into the plasticizer created new fields for vinyl plastic. The growth of polyester resins has been slow because of lack of suitable machines

The development of machines is a very costly process, much more so than the development of materials. This is especially true when the size of the piece to be fabricated is large. Moreover, at present a large number of machines cannot be sold and, therefore, incentive for the development of radically new machines is slight. As the industry grows, however, this condition will change and a great impetus to the use of plastic materials will result.

Petroleum as a Raw Material for Plastics

Petroleum is already the largest single source of raw materials for plastics. For example, the exclusive raw material for polyethylene is petroleum ethylene. The urea formaldehyde resins are also 100 per cent pertoleum derived products, as urea itself is made from natural gas via ammonia, and formaldehyde from natural gas via methyl alcohol. Benzol, used both for styrene and phenol, formerly was entirely a coal-tar product. In 1953, one-quarter of the raw materials came from petroleum, and in 1954 one-third was so derived.

Table 2 lists various plastic materials, amounting to 80 per cent of the total 1953 production, and includes the major plastics. The first column gives the total weight of plastic produced and the second column the net amount (the total less filler, etc.). The third column shows the pounds of petroleum product required for the manufacture of each material. In this estimate, urea, methanol, acetic acid, and ethylene are considered as derived entirely from petroleum. Ninety-three per cent of phenol is synthetic and one-quarter of that is considered to be derived from petroleum benzol. Twenty-three per cent of the glycerine and 10 per cent of the phthalic anhydride, all the pentaerythritol, and all the ethylene glycol are considered petroleum-derived.

TABLE 2. Raw materials for Plastics U. S. 1953

Millions of Pounds

	Plastic materials*	Plastic materials less filler, etc. (estimated)	Petroleum raw material
Total U. S.	2777		
Vinyl resins	516	437	156
Styrene resins	508	500	232
Urea-formaldehyde	194	165	205
Melamine-formaldehyde	63	53	21
Polyethylene	140	135	135
Phenolics	459	347	167
Phthalate resins†	321	321	72
Total	2201	1958	988

* From U. S. Tariff Commission Report No. 194 Second series.
† Calc. to unmodified resin.

On the average about one-half pound of raw materials of petroleum origin is required for each pound of plastics listed. One of the most prominent plastics, polyvinyl chloride is more that 50 per cent chlorine. Therefore, less than half of the organic raw materials required for plastics come from non-petroleum sources, principally coal-tar and acetylene. Increasing amounts of acetylene will come from petroleum, however, and will further increase the importance of petroleum as a raw material, particularly in the manufacture of several promising monomers such as acrylonitrile and the acrylates.

Coal-tar production is dependent on coking operations, which in turn are fixed by steel production. Fig. 4 shows the growth of the steel industry and of the plastics industry on a semi-logarithmic scale. As can be seen, plastics are growing at a much more rapid rate than steel and are therefore outstripping the raw material supply from coal-tar. The situation is further accentuated by the increasing demands from other branches of chemical industry. To an increasing extent the petroleum industry is making up for limitations in the growth of coal-tar raw materials; at the same time it is increasing its production of those raw materials that are uniquely petrochemical.

In this discussion synthetic rubber and synthetic textile fibers have not been included. Styrene-butadiene and acrylonitrile-butadiene rubbers are largely petrochemical products. The probability is that nylon eventually will be almost entirely derived from petroleum via cyclohexane. Acrylonitrile fibers are 100 per cent petrochemical. For the Terylene (Dacron) fiber, ethylene glycol, and isophthalic acid are required. Glycol is, of course, a petroleum product. Terephthalic is made from p-xylene, most of which will be manufactured from petroleum.

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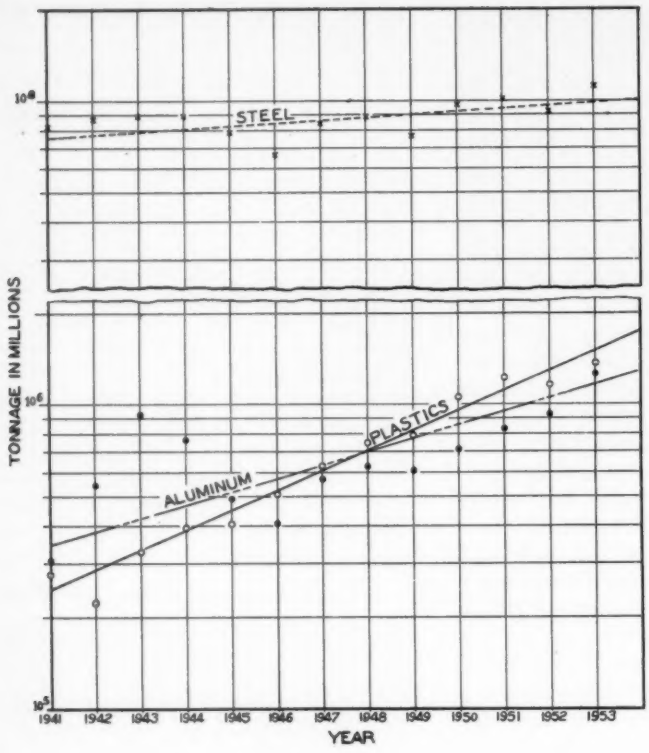

FIG. 4. Semi-logarithmic chart shows growth of U. S. steel, aluminum, and plastics production

FIG. 5. New markets are created by new plastic products, as in this case where spraying of lawns becomes inexpensive and easily handled with a new lightweight vinyl plastic hose

Plasticizers

Plasticizers are materials added to plastic compositions to modify their properties and/or facilitate their fabrication. True plasticizers are solvents for the basic plastic material and remain permanently in the composition. Some plastics, for example, cellulose nitrate, are not workable without plasticizers; others, for example, polyethylene, do not require any plasticizer.

The use of a properly selected plasticizer improves physical properties, such as toughness, flexibility, extensibility, etc. While plasticizers are the means of improving certain plastics, their use usually involves a compromise as they often adversely effect other properties of the product. For example, an oil soluble plasticizer may be extracted on contact of the plastic material with such solvent. Problems that arise on the use of plasticizers are due to volatility, migration, solvent susceptibility, and chemical change of the plasticizer itself. It is preferable to modify the basic material so that very little plasticizer, if any, is required. There is a noticeable tendency to avoid plasticizers. Although the total volume of plasticizers used is increasing, the average per unit of plastic is decreasing. At present it is about 10 per cent and will continue to decrease as current plastic materials are modified and new materials are developed. There was an acute plasticizer shortage immediately after World War II but since then the situation has eased.

To an increasing extent plasticizers are also petroleum-based. Generally they are esters of higher alcohols or glycols and polybasic acids. The glycols are entirely petroleum products. Higher alcohols have been made from acetaldehyde (a petrochemical derivative) by aldol condensation and hydrogenation reactions. The petroleum industry is also beginning to supply large quantities of higher alcohols produced from olefins by the Oxo process, the lowest cost process. The two principal acids are phthalic acid (anhydride), already produced in part from petroleum via o-xylene, and adipic acid, which is made in large volume from petroleum cyclohexane. Isophthalic acid from petroleum m-xylene is one of the new dibasic acids.

Composite Plastic Structures

Plastic materials are often compounded with so-called inert fillers, particularly in molding compositions, and in laminates of paper, glass fiber or fabrics. These composite structures offer improved properties such as greater shock resistance, better electrical insulation, higher temperature resistance, etc. Plywood with a synthetic resin interlayer is superior in many ways to the older types of plywood. The wood part of the structure is essential, and so far no plastic is capable of being fabricated by itself into very large pieces and with serviceable strength. The same is true of glass fiber polyester materials. Another example, somewhat in reverse, is the use of a plastic inner layer for safety glass. Without the inner layer the structure would not have the safety features (Fig. 5).

Composite structures have not perhaps received the attention that they merit but in recent years there have been some notable developments. The combination of polyethylene and aluminum for cable insulation and protection is one example. Another is the use of nylon cords in automobile tires. This latter is somewhat unique in that both partners in the composite structure are synthetic plastics.

Organization of the Industry

In the early days, the manufacturer of plastic material was an intermediary between the producer of the chemical raw material and the fabricator. He purchased the phenol and formaldehyde to produce the molding compound that he sold to molders who fabricated molded parts for sale to others or for his own use. **In recent years there has been an integration of plastic materials manufacture into the chemical industry and manufacturers of plastic materials have integrated backwards into the manufacture of their own chemical raw materials.**

For example, General Plastics, Reichhold and Bakelite have gone into the manufacture of phenol and formaldehyde. Similarly manufacturers of chemicals have integrated forward into the manufacture of plastic materials. Monsanto and Koppers are two examples of this tendency. In like manner, synthetic fiber and rubber producers have recognized the close re-

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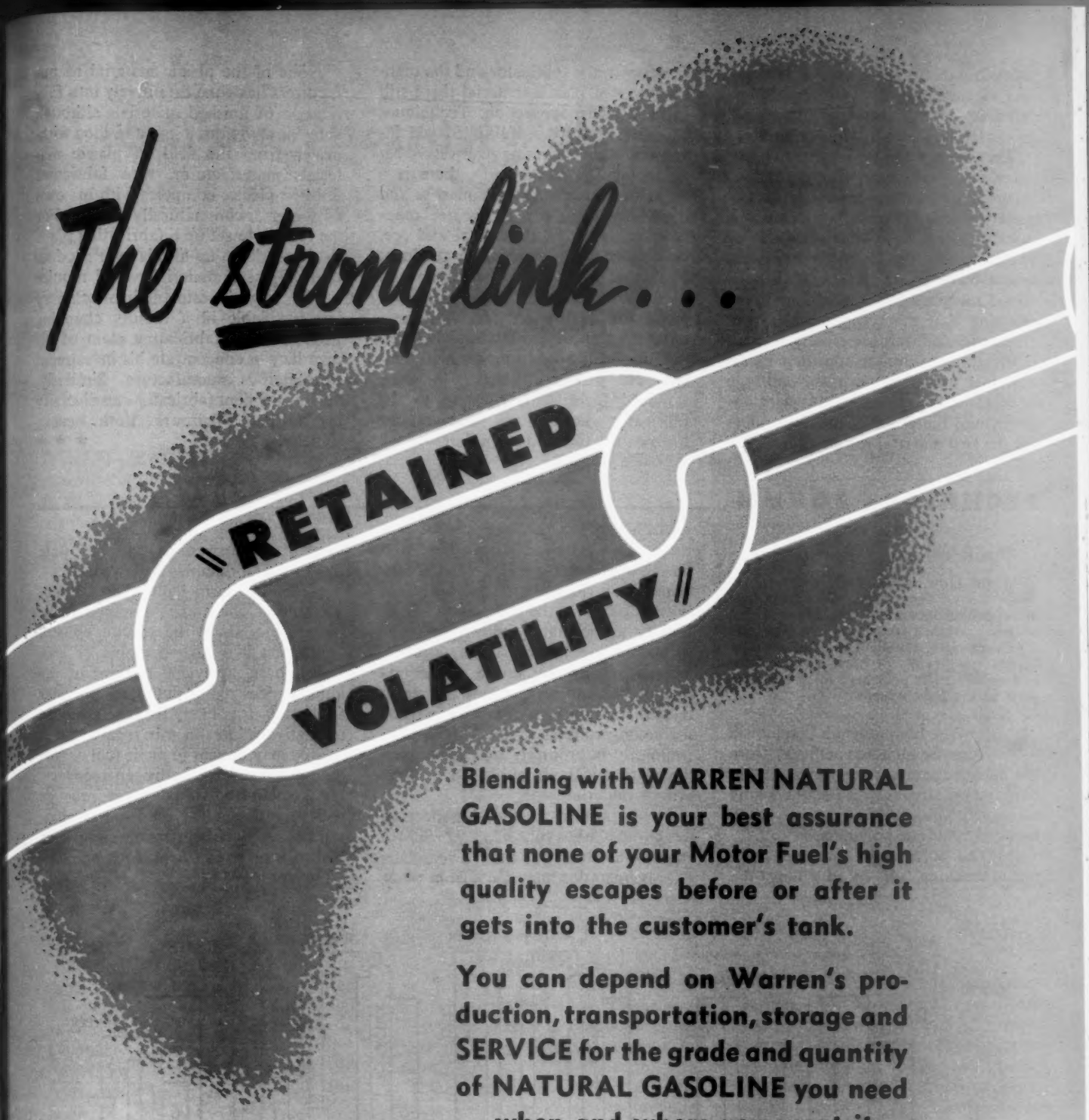

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lationship between their old business and the new industry. Celanese offers cellulose acetate molding compound, Goodrich and others, vinyl resins.

There is another movement that has taken place in recent years: Horizontal integration for the production of a variety of plastic materials. Very few manufacturers now offer only one or two materials. The larger ones have extensive varieties of plastics. Such horizontal integration has been a result of realizing that marketing problems of all plastic materials are closely related, fabricators are broadening their facilities, that for many purposes one type of material is not competitive with another, and there is advantage in offering the best material for any job.

Between the fabricator and the manufacturer of plastic material there still exists a sharp separation. Techniques of fabrication have multiplied and investments in fabricating plants have become very large. Actually, there is a close analogy between the plastics and metallurgical industries. The steel manufacturer may purchase coal and ore, or own his own mines. He produces steel in standard shapes, which he sells to shops that fabricate for their own use or for distribution. The plastic material manufacturer may buy chemical raw materials or may make them himself. He produces plastics in some standard form. This goes on to the fabricator who produces structures for his own use or for distribution.

None of the plastic material manufacturers has gone extensively into fabrication of finished materials although some have ventured into and then withdrawn from the field. A plastic materials manufacturer, who fabricates finished pieces, competes with his own customers, who naturally object. For the former to set up a fabricating plant that would use up all his own production of plastic material would require a very large investment in machinery not justifiable in a rapidly changing field. With no fabricating plant of his own he can concentrate his investment in materials manufacture. Similarly, the independent fabricator can diversify his finished products. Both benefit thereby. * * *

TECHNICAL FORUM

Purification of Butadiene

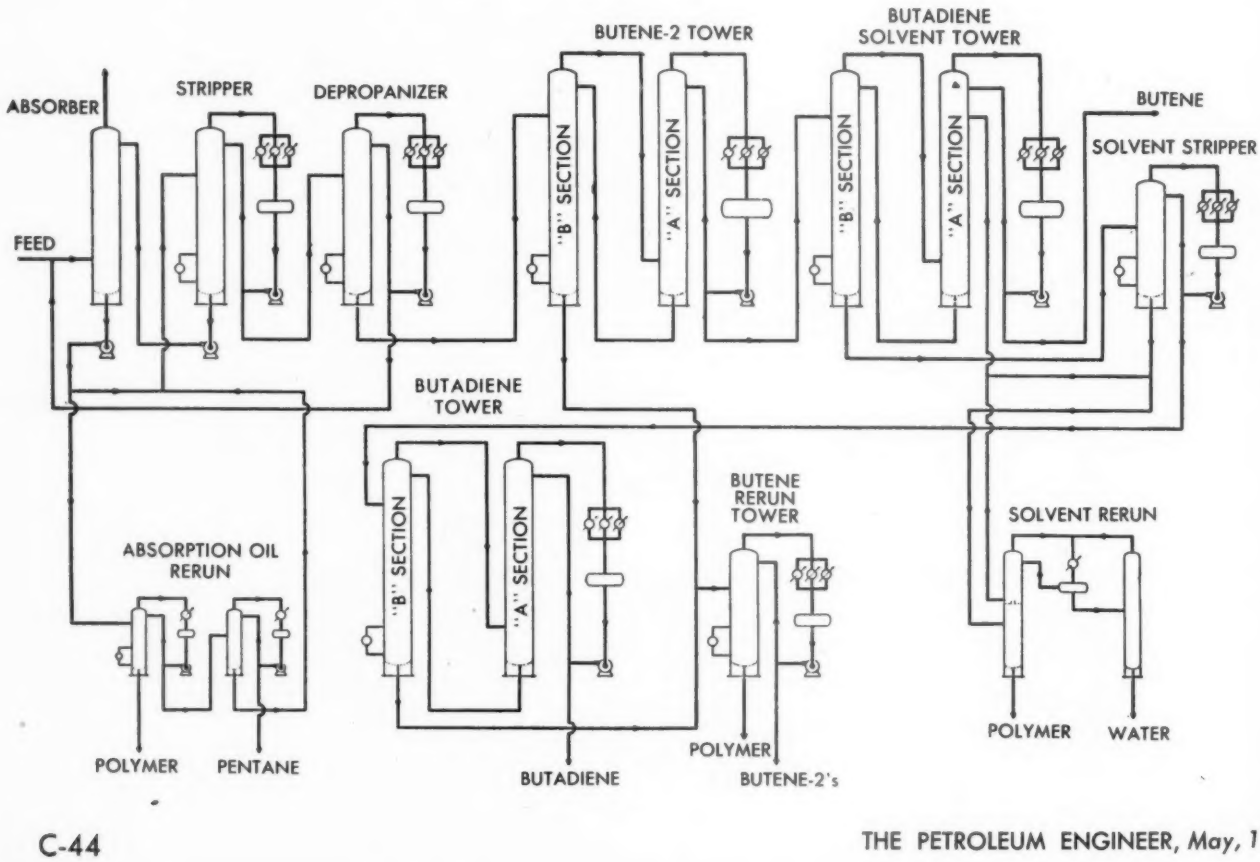
Q (a) How is the high polymer removed from the crude butadiene after dehydrogenation? (b) How is the polymer stripped from the quenching oil? (c) Can a clear flowsheet of what actually occurs be given? (d) How do the light hydros affect the polymer? (e) What happens to the light hydros?

A (a) The high polymer is removed from the butadiene effluent from the dehydrogenation reactor by scrubbing the gas stream with the quenching oil which absorbs the relatively high molecular weight polymers.

(b) The polymer is separated from the quenching oil by distilling the major portion of the oil overhead and taking a polymer-quench oil as a bottoms. It is important that sufficient quench oil be in the bottoms to insure fluidity at normal handling temperatures and also to provide the dilution adequate to prevent undue concentration of hazardous peroxides and polymers that might be spontaneously flammable on exposure to air. This residue ordinarily is promptly burned as produced to avoid accumulation of hazardous materials.

(c) A portion of the flowsheet in Trans. AIChE, vol. 42, 192 (1946) shows quench oil handling. The details of this operation may vary from plant to plant but answers (a) and (b) state the general principles followed.

(d, e) The term light hydros is not a common one and is assumed to be those materials in the reactor effluent containing two carbon atoms or less. Possibly the acetylene content of the light hydros contributes to polymer formation. It is likely that the ethylene is relatively inert in this regard. Light hydros may be sent to plant fuel or further processed for hydrogen recovery. Here again individual plant practice will vary depending on local circumstances. A flowsheet mentioning light hydros is given in *Chem. Eng.* pp. 306-309, Sept. (1954). *J. H. Boyd.*



Multiple-Viscosity Motor Oils Analyzed

Muti-grade oils save octane numbers, reduce engine wear; question is: How many, and how much?

EUGENE B. BRIEN*

MULTI-GRADED motor oils—currently hotly debated—came into sharp focus in the symposium on "An Evaluation of Multiple-Viscosity Graded Motor Oil" at the 52nd annual meeting of the National Petroleum Association at Atlantic City in mid-September. Four separate research teams asked and answered: Do multi-graded oils help engine knock? Do they decrease combustion chamber deposits? Do they save fuel? Do they reduce engine wear?

Multi-viscosity graded motor oils differ from conventional oils in being prepared from distillate oils boiling within relatively narrow ranges. With the addition of viscosity index improvers that control their viscosity at engine operating temperatures, their VI is generally above 100 so that one formulation can meet the viscosity specifications for several different SAE grades.

Engine Knock and Deposits

Research by the fuels and lubricants department of General Motors showed that the multi-graded oils make a significant reduction in fuel antiknock requirements and show a marked superority over bright-stock-based oils, said R. K. Williams in his paper, "Do Engines Like All-Weather Oils?"

Conventional bright-stock oils make heavy combustion chamber deposits and high fuel antiknock requirements, compared to the new high VI type oils, he continued; their octane requirement increased by 8 as compared to a range of 1.5 to 4.2 for the newer oils.

Quaker State Oil Refining Corporation's findings were in substantial agreement, according to Carl Georgi in his paper, "How Good Are the 'New' Type Motor Oils." He does not believe though that the newer oils could save much more than from three to five octane numbers under even the most unfavorable engine operations.

The primary reason for the problem, he said, is the high compression engine.

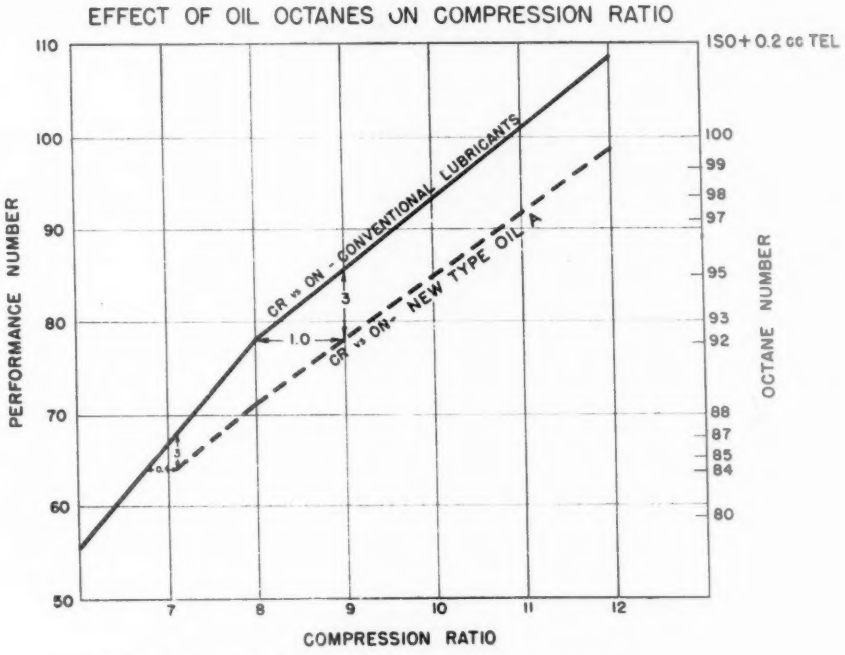


FIG. 1. Effect of oil octanes on compression ratio.

A 7.5-1 engine existed in 2 models in 1950; this year it is found in 22 engines and 8 of these are between 8.0 and 8.7-1.

Engine operation is also a strong factor. In an engine operating under constant speed and load, oils have practically no effect on the type or amount of deposits formed, he reported. The predominant factor is the lead deposits. Under heavy duty, cross-country driving, chamber deposits are practically identical whether the conventional or the newer oils are used, Georgi continued, and carbonaceous matter is a minor part of deposits.

With the volatile oils, chamber deposits were smooth and vitreous in car tests; with conventional oils, deposits were irregular and cracked. But in both cases, Georgi said, 70-80 per cent of the deposits were lead salts and inorganics and in both cases octane requirement increases were 6-8. Even oils having a minimum deposit forming tendency bring the octane requirement number up to 10. He rejected the contention that burned oil builds deposits; they simply act as binder for the lead salts.

Oils with a greater percentage of bright stocks lead to higher carbon-lead-salt ratios in deposits, according to L. Raymond and J. F. Socolofsky of Socony-Vacuum Oil Company (Fig. 1). SAE 10W and 30 grade distillates raised the octane requirement by 1 number, but an SAE 30 blend of distillate and bright stock raised it by 7. Different additive concentrations in commercial fuels and detergents do not affect the required increases, they said. The newer formulations showed a consistent and relatively large reduction in octane requirement increase; average reduction was 3, largest was 9.

R. L. Overcash, W. Hart, and D. J. McClure, Kendall Refining Company,

EXCLUSIVE

*Eastern Editor.

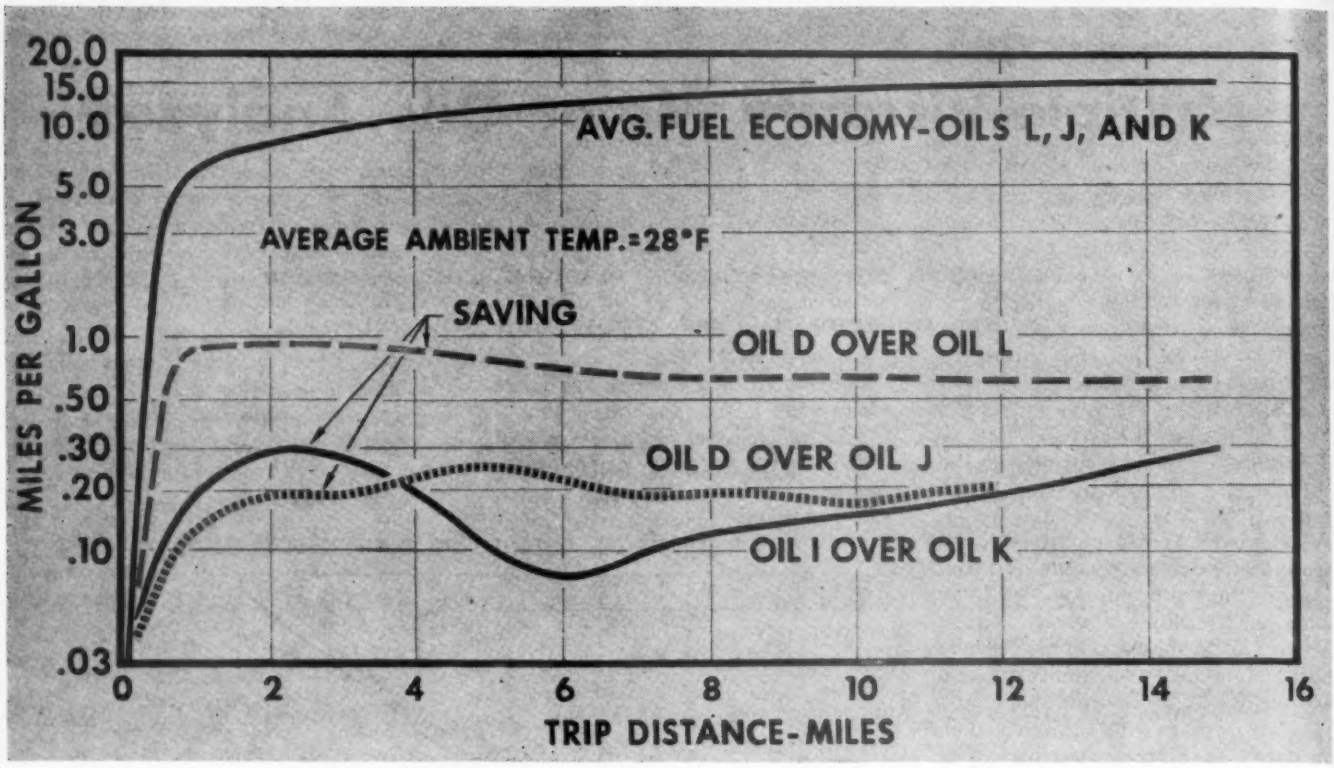


FIG. 2. 30 mph level road test: Fuel savings in miles per gallon for high VI oils (Oil D: SAE 5W-20) (KJL: conventional oils).

in "10W-30 Motor Oil: Several important Performance Characteristics," held that multi-graded oil was a real improvement over conventional SAE 20 in lowering octane requirement increases. Reduction in requirement ranged from 16 to 2 at full throttle and from 24 to 5 at part throttle. Reduction in chamber deposit weight fell from 84 grams for conventional oil to 37 grams from the 10W-30 formulation.

In road tests, the 10W-30 octane requirement increase averaged 6 numbers less than for conventional oils, they found. Equilibrium octane levels in each car tested averaged 5.5 octane numbers lower.

Fuel Economy

General Motor's Bidwell declared that the multi-graded oils gave a small, but definite, increase in fuel economy by reducing engine friction. In 30 mph road tests, savings of from 5-16 per cent were recorded for 10W-30 compared to the 30 oil (Table 1). Saving in fuel was particularly notable during starting periods where it reached a high of 30 per cent, but this fell to about 4 per cent for trip distances over 8 miles. For SAE 5W-20 as compared to SAE 20 oil, fuel savings decreased from 6 per cent under starting conditions to 2 per cent or less for distances over one mile. Similar results were obtained for other oils. In terms of miles per gallon, the motorist could get somewhat less than one mile more per gallon with the newer oils, he said.

In highway tests, however, average fuel economics indicate no consistent relationship between oil VI and fuel economy. Hence, Bidwell concluded that high VI oils have no economic advantage over conventionals oils of comparable viscosity.

Georgi estimated that a change of one SAE viscosity grade made a change of 2-3 per cent in miles per gallon; thus, SAE 10W could give 5-6 per cent more mileage than 30 grade. But, he reported, in typical city traffic and in mild winter weather, atmospheric temperature and engine warm-up time are greater factors than viscosity or viscosity index. The colder the weather, the poorer the gas economy under such short-run, cold operating conditions. Differences in motor oils produce only a fraction of changes in miles per gallon, he stated.

Raymond explained that a 5-10 per cent reduction in fuel consumption in typical cars can come with the newer oils from reducing friction during starting, warm-up, and in normal operations. By improving volumetric and thermal efficiencies through improved combustion chamber conditions and spark-plug operation, the newer oils reduced waste of fuel. Service experience shows total gains in fuel economy may be very large in some cases.

Engine Wear

Of several, new high VI crankcase oils tested on cam and lifter wear test in two engines with three metallurgical combinations, none of the oils was satisfactory in anti-wear properties, Bidwell reported, a fact probably due in part to the additive formulations used. By adding zinc dithiophosphate to the oils, pitting of chilled iron lifters was completely eliminated. Similar reductions, he said, were also made in lifter length loss and cam wear for chilled iron lifter, steel cam combination. Suitable anti-wear agents improve oil performance (Table 1).

TABLE 1. Cam and lifter wear measurements with new high VI oils.

		LS-5 results			LS-6 results					
					Steel lifters		Alloy iron lifters		ORI-1 results	
Oil	SAE grade	Pitting severity per cent	Lifter length loss	Cam wear	Lifter wear	Cam wear	Lifter wear	Cam wear	Lifter wear	Cam wear
E	5W-20	50	10	13	44	5	7	9	3.6	5.2
A	10W-30	54	17	65	73	11	4	8	4.9	3.8
P	5W	62	26	101	81	498	4	12	...	...
B[1]	10W-30	62	18	94	78	87	8	12	3.7	4.5
C[1]	10W-30	67	28	212	124	18	7	10	21.5	7.5
Q	5W-20	74	22	90	20	6	5	6	...	...
H[2]	10W-20	75	24	96	79	157	8	9	32	56
F[2]	5W-20	92	32	206	157	318	10	10	130	144
I[1]	10W-30	100	31	161	130	22	7	12	...	...
D[1]	5W-20	100	42	340	152	22	8	13	...	...

NOTE: 1 Contains some phenol type additive.
2 Does not contain any zinc dithiophosphate.
(All wear values are shown in tenths of thousandths of an inch)

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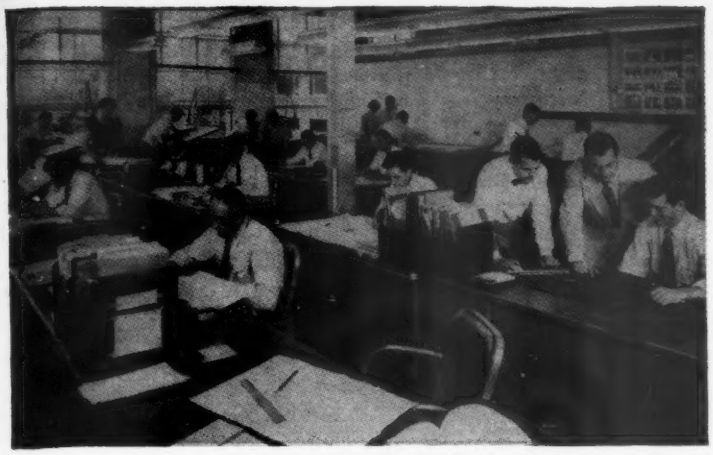

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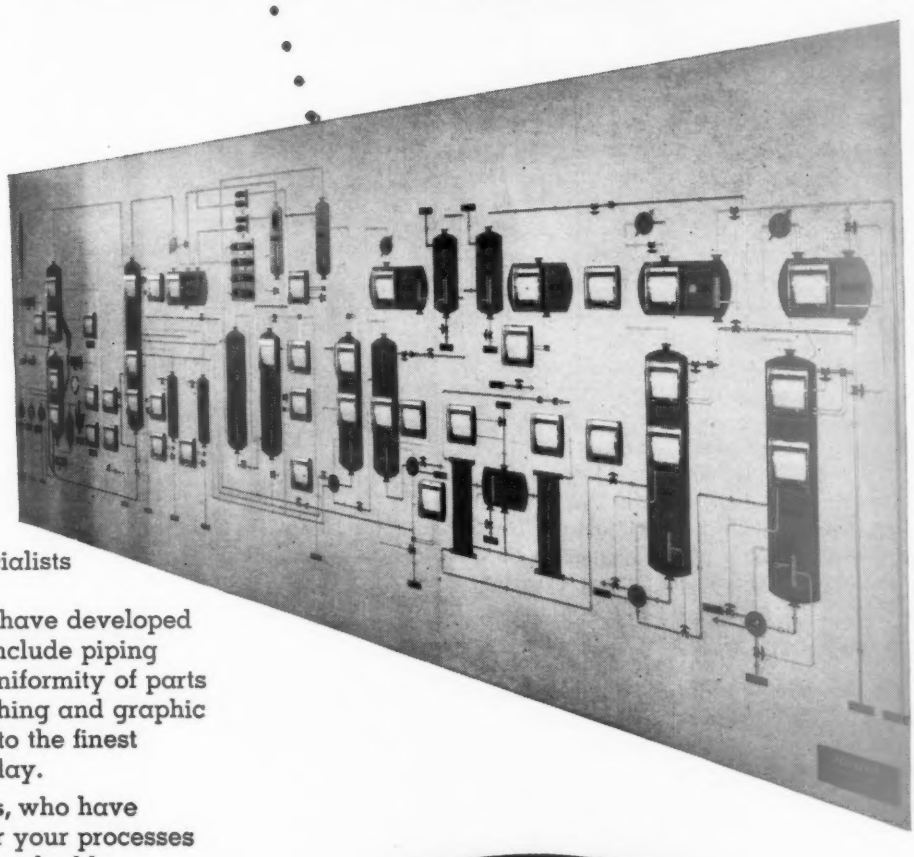

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Georgi explained that no oil can overcome abrasive wear in an engine. Commercial motor oils have detergent additives highly effective as anti-corrosive and anti-erosive agents for rings and cylinders compared to straight mineral oils.

Bright stock oil was much superior in minimizing valve and lifter failure, he held, than straight distillate type oil of similar viscosity. He added that the longer engine life of the modern engine is attributable as much to improved engine design and better metallurgy as it is to improved oils.

Although Raymond conceded that viscosity may have a measurable effect on wear and scuffing in certain situations, he held it was a negligible factor compared to the influence of additives. With conventional oils, wear increases appreciably with decreasing temperatures. At the lower temperatures wear protection from straight mineral oil and a MIL-0-2104 oil of conventional base stock formulation differs largely. A cross-graded oil of lower viscosity at low temperatures gave lower wear than conventional SAE 2-W oil of like additive content.

* * *

Ratings Highest on East Coast, Texas Coast . . .

Slight Octane Number Rise in March

Only slight increases in the average octane ratings of premium motor fuels in 53 cities in the United States were shown by the March, 1955, Ethyl Corporation's gasoline survey, as compared to February results. This agrees with results from other investigations and surveys, but all fit into the pattern of the very gradual and inevitable climb of the octane number curve. According to this survey, regular gasolines showed practically no change except on the West Coast, where an average boost of 0.4 octane numbers was found. The overall average increase for premium fuels was only 0.2 octane numbers.

National *weighted* averages for premium fuels was 94.9 in March. For regular fuel grades it was 87.5, corresponding with other findings. The highest premium grade average in the country was 96.6, at Corpus Christi, Texas. The highest regular grade was 90.0, shown at four cities — Baltimore, Maryland; Boston, Massachusetts; Jacksonville, Florida, and Philadelphia, Pennsylvania. Highest TEL content of premium fuels was in Bakersfield-Fresno, California, 2.82 cc per gal. In regular grades the largest amount was 2.62 cc per gal, in Buffalo, New York. Premium fuels containing the smallest amount of TEL were tested from Salt Lake City, with 1.12 cc per gal. All but a few averages showed more than 2 cc for premium fuels. For regular fuels the minimum shown was 1.10 cc, with the majority of averages between 1.50 and 2.50 cc. The accompanying condensed table shows the averages as reported.

Strangely enough, octane numbers seem highest on the East Coast and the Texas Coast, ranging from 96.0 to 98.0 of the premium variety with 96.0 octane number at such widely separated points as Little Rock, Arkansas, and Philadelphia, Pennsylvania, Casper, Wyoming, in the height of the Rockies, also Denver, Colorado, have about 90.0 octane number each. The difference in Research and Motor method octane numbers ranges between 8 and 10 numbers, throughout. References between Research and Motor octane number in regular grade fuels vary even more widely, from 5 to 7 octane numbers, with as low as 4.6 at Wichita, Kansas, long the "battleground" of motor fuel quality in the Midwest and Mid-Continent areas.

Ethyl Corporation gasoline survey for March, 1955.

	PREMIUM			REGULAR		
	Octane number		TEL content	Octane number		TEL content
	Research	Motor	ml/gal	Research	Motor	ml/gal
Albuquerque, N. M.	93.5	85.4	2.56	84.0	79.9	1.85
Amarillo, Tex.	92.8	84.6	2.32	84.0	81.0	1 99
Atlanta, Ga.	95.8	85.9	2.32	87.5	82.5	2.02
Bakersfield-Fresno, Calif.	94.2	87.2	2.82	84.5	78.0	1.47
Baltimore, Md.	96.4	86.0	2.51	90.0	83.4	2.50
Billings, Mont.	92.8	83.1	1.47	86.0	81.0	1.13
Birmingham, Ala.	96.0	85.4	2.41	87.1	81.9	2.14
Boston, Mass.	95.8	85.6	2.12	90.0	83.2	2.19
Buffalo, N. Y.	95.2	85.5	2.80	89.8	84.1	2.62
Casper, Wyo.	90.2	81.8	1.65	83.0	78.6	1.10
Central Mich.	94.3	85.7	2.55	87.9	81.2	2.61
Charlotte, N. C.	95.7	85.4	2.39	87.4	81.1	2.34
Chicago, Ill.	92.8	84.4	2.12	84.7	80.4	1.92
Cincinnati, Ohio.	94.8	85.0	1.93	88.8	82.3	2.14
Cleveland, Ohio	94.8	84.9	2.13	88.8	82.5	1.79
Corpus Christi, Tex.	96.6	87.5	2.72	86.9	83.1	1.96
Dallas-Fort Worth, Tex.	95.6	86.2	2.68	85.9	81.0	2.42
Denver, Col.	90.5	81.8	1.76	83.5	79.2	1.59
Detroit, Mich.	94.0	84.9	2.15	88.7	81.9	1.94
El Paso, Tex.	93.7	85.5	2.24	82.9	79.2	1.59
Fargo, N. D.	92.2	85.2	2.13	84.8	80.5	1.56
Hartford, Conn.	95.2	85.9	2.51	89.9	83.6	2 50
Houston, Tex.	96.2	86.2	2.79	86.5	82.5	2.25
Indianapolis, Ind.	93.6	84.5	2.05	86.5	80.5	1.46
Jackson, Miss.	95.6	85.4	2.51	87.4	81.9	2.48
Jacksonville, Fla.	95.6	85.7	2.28	90.0	83.1	2.39
Kansas City, Mo.	92.1	83.9	2.18	84.7	80.1	1.64
Little Rock, Ark.	96.0	85.5	2.43	87.1	81.7	1.95
Los Angeles, Calif.	94.3	83.3	2.38	85.0	79.6	1.51
Louisville, Ky.	95.2	85.0	2.38	87.2	81.4	2.39
Memphis, Tenn.	95.6	85.3	2.31	87.6	81.6	1.97
Metropolitan N. Y., N. J.	95.9	85.6	2.15	89.9	83.8	2.12
Milwaukee, Wis.	94.5	85.6	2.20	85.5	80.2	1.69
Minneapolis-St. Paul, Minn.	92.2	84.0	2.16	84.9	80.0	1.77
New Orleans, La.	96.0	85.8	2.70	87.6	82.5	2.36
Northwest Pa.	94.3	87.8	2.46	89.6	84.2	2.55
Oklahoma City, Okla.	93.3	84.6	2.19	84.1	79.8	2.08
Omaha, Nebr.	92.3	84.5	2.28	84.7	80.1	1.66
Philadelphia, Pa.	96.0	85.6	2.21	90.0	82.8	2.28
Phoenix, Ariz.	94.6	84.7	2.02	84.8	79.6	1.46
Pittsburgh, Pa.	95 8	85.8	2.46	89.9	83.3	2.21
Portland, Ore.	94.3	84.1	2.22	85.1	80.0	1.41
Richmond, Va.	95.8	86.1	2.37	89.5	82.9	2.15
Salt Lake City, Utah	90.4	82.4	1.12	82.1	78.8	1.25
San Antonio, Tex.	95.4	86.7	2.78	86.6	82.3	2.13
San Francisco, Calif.	94.7	83.6	2.27	85.2	79.7	1.27
Seattle, Wash.	94.2	85.0	2.00	84.7	80.0	1.47
Shreveport, La.	94.9	85.4	2.56	86.5	82.2	2.46
Spokane, Wash.	93 7	83.4	2.12	84.8	79.7	1.45
St. Louis, Mo.	92.8	84.6	2.24	84.9	79.9	1.74
Toledo, Ohio	94.4	84.9	2.12	88.7	82.3	1.55
Tulsa, Okla.	92.2	85.0	2.36	84.2	80.2	1.49
Wichita, Kansas	92.2	85.0	1.99	84.6	81.0	1.78

Reduces cost, space requirements . . .

COMPACT DESIGN FOR NEW OIL EXTRACTOR

. . . is stainless steel, centrifugal type

COLLIN M. DOYLE and EDWARD RAUCH*

FLEXIBILITY in design and long lasting eye appeal were two of the principal achievements of arc welded stainless steel in a new type of lubricating oil extractor known as the Petrozon. It is a centrifugal counter-current solvent extractor, considerably more compact than the gravitational towers and mixer settling tanks conventionally used for refining highest grades of lubricating oil.

Machines based on the same principle of continuously handling two immiscible liquids of different densities have been built to produce penicillin, chloromycetin, terramycin, and other antibiotics; their adaptation to petroleum processing is relatively new.

†Abstract of a prize-winning paper in the recent Mechanical Design Competition sponsored by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

*General manager, and manager, Podbielniak Inc., Chicago, Ill.

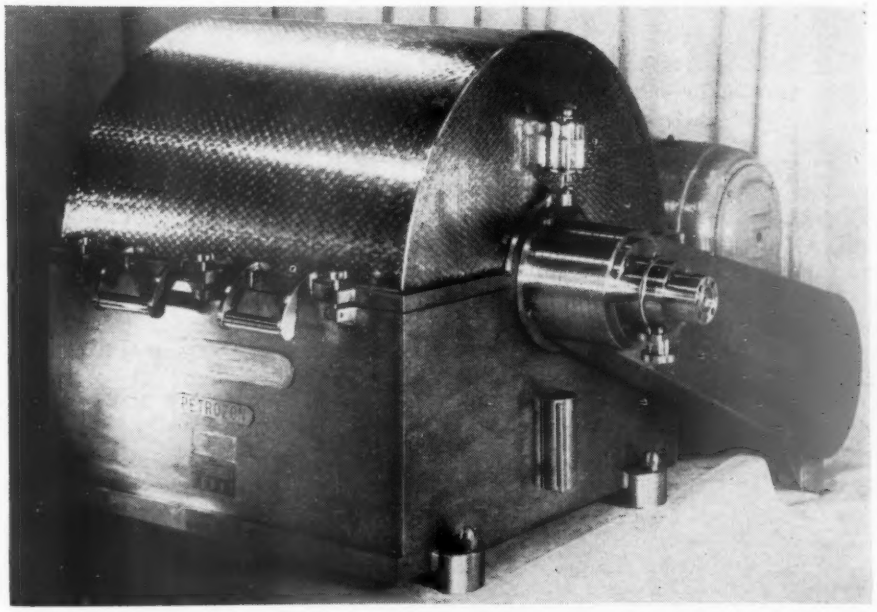
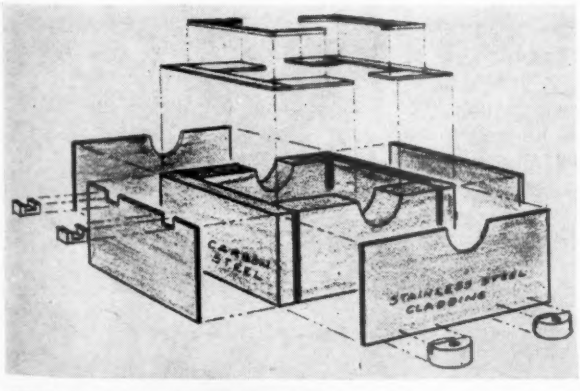


FIG. 1. Centrifugal extractor for refining of high grade lubricating oils is pleasing in appearance and maintained easily.

FIG. 2. Four base sections are clad on the sides and top with stainless steel.



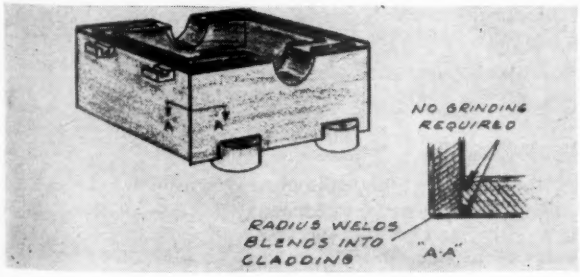
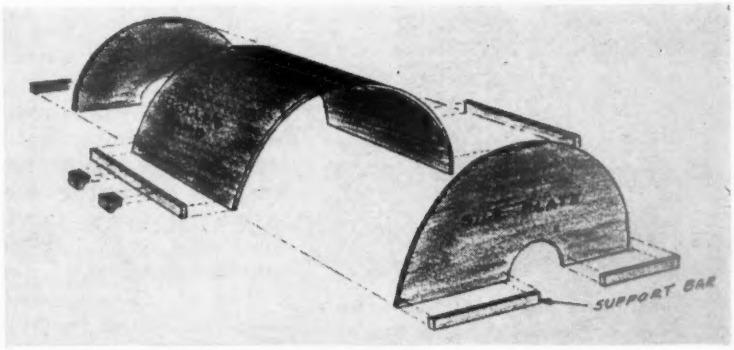
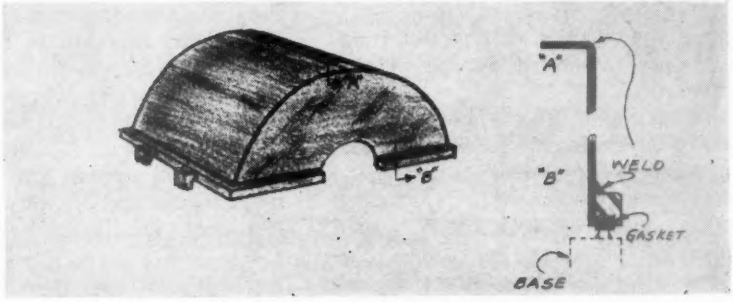


FIG. 3. Elements of the upper enclosure are welded after tacking, with no fixture needed other than the base of the machine.





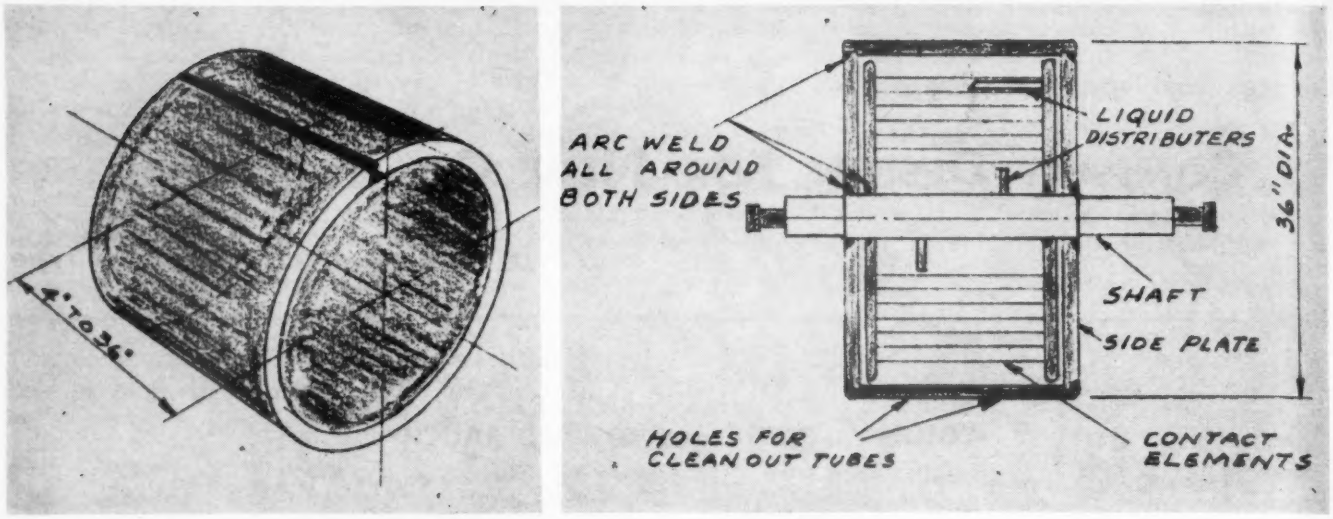


FIG. 4. Rotor band is vee-welded as indicated and made in various widths for different size extractors. The welded assembly gives considerable flexibility.

Design requirements include safe construction, simple operation, and low maintenance. Corrosion-resistant material is demanded because cleaning out the carbon build-up, after a period of operation, is done with solutions that would attack carbon steels. Speeds up to 2500 rpm are necessary to develop the high gravitational (5000 g) force essential to produce the desired action between the oil and furfural solvent;

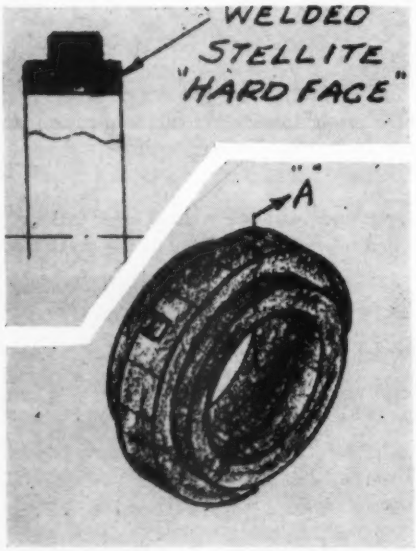


FIG. 5. Hardfaced mechanical seal on the surface receives the most wear.

hence, the selection of type 316 stainless steel, assembled by arc welding techniques.

The extractor, Fig. 1, has clean, trim lines contributing to pleasing appearance and easy maintenance. The base, of composite construction as indicated in the sketch, Fig. 2, is first fabricated from 3½-in. thick hot rolled low-carbon steel plates and then clad with ⅛-in. stainless sheet, in the interests of conserving high cost alloy steel. Arc welded construction eliminates the need for patterns, cores, and molds inherent in a cast design, and also permits considerable flexibility in varying the size of the machine. The extractors are furnished in a variety of capacities according to the output rates of the refinery installing them.

Sequence of assembly and welding the base elements is as follows:

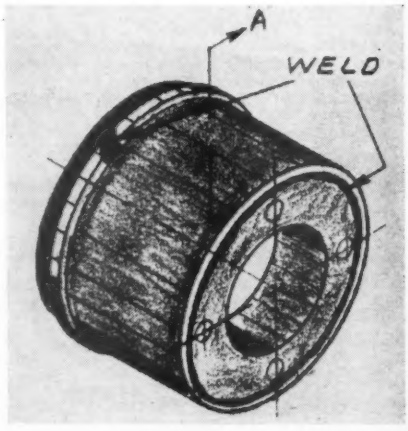
Four sections of the heavy plate weldment are clamped to the table of a mechanized welding positioner. They are tacked and manually welded horizontally, using 5/16-in. mild steel rod and straight polarity. Result is a flat and flush weld that does not require grinding for subsequent cladding operations. A normalizing treatment is given the assembly to relieve possible welding stresses.

Stainless steel cladding sheets next are clamped to the base weldment and tacked in position. Corners are set at 90 deg to form a right-angle groove for the weld deposit as shown in the sketch. The weld is made in a horizontal plane with 3/32-in. type 316 stainless steel rod and reverse polarity. A generous radius is formed and little finishing is needed to blend it perfectly into the cladding.

The stainless sheath completely covers the outside, inside and top of the base. Inserted into a milled groove on the top is a square tongue held in place by welding the ends to the cladding. It forms the male members of a tongue-and-groove water-tight seal between the base and top enclosure.

The latter, Fig. 3, comprises 2 side plates, a rolled band, 6 support bars, 2 hinge blocks and 2 knobs, all of stainless steel. The rolled band is placed on edge on a welding table, and one side plate laid on top of it. The band need not have a perfect radius as it is tacked onto the side plate and thereby formed to a true semi-circle. Welding rod again is ⅛-in. type 316 stainless desposited with reverse polarity at 125 amps.

Support bars are tacked into position, the base assembly being used as a fixture. The finish weld is a fillet be-



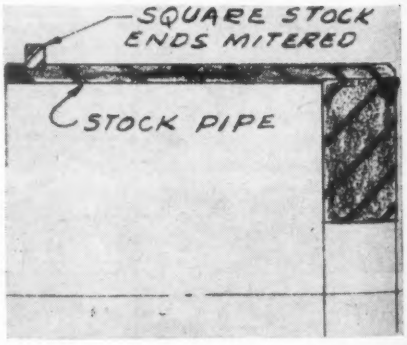


FIG. 6. Simple seal housing bracket design reduces cost, saves material. It is assembled by welding standard stock shapes.

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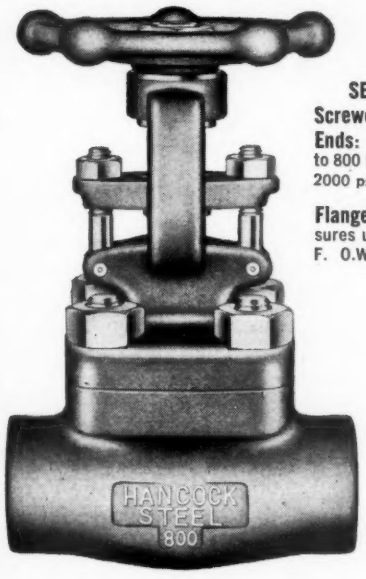

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tween the side enclosure and the support bar. Hinges and fastening knobs are lined up with their matching parts on the base and fillet welded into place.

The extractor rotor is of 1½-in. stainless plate rolled to a 36-in. diameter cylinder, Fig. 4, and secured with a double-Vee arc weld. It might have been specified as a forging, but the use of plate stock was figured to provide greater strength and the material was much more readily available. After the rotar has been rough machined and scarfed, the side plate is welded to it and also to the shaft. One inner plate is welded to the shaft after which the contact elements and liquid distributors are assembled and the second inner plate welded to the shaft. Finally the outer plate is assembled and welded to the shaft and to the rotor shell. Proper preparation of the weld areas, careful application of weld metal followed by liberal peening and cooling after each pass insure that warpage and eccentricity of the finished rotor are limited to a small fraction of an inch.

Mechanical seals, Fig. 4, are of stainless steel with a stellite wear surface arc welded as shown. This surface is ground and lapped flat to within one light band. Thus, welding has reduced grinding and costly finishing operations on the hard surface to a small area. Both investment castings and powdered metal compacts were considered as alternate for mechanical seals, but were discarded because of the cost of molds and dies and the more difficult overall finishing operations they would involve.

On several other small components, the arc welding of standard stock shapes was practiced wherever possible to effect economy in material and reduce machining costs. The seal housing bracket, Fig. 6, is a good example. A simple belt guard is formed by arc welding two preshaped pieces of ⅛-in. stainless sheet, eliminating possible noisy vibration arising in a bolted or screwed design and increasing the safety factor of the guard. No fixtures were required for this assembly. Limited quantities, of course, precluded a single piece press-formed shape.

It is readily seen that the centrifugal extractor may be cleaned with little difficulty and with none of the hazards attending high gravitational towers or settling tanks. Likewise, it is installed quickly without the aid of construction or erection crews. Beyond that, arc welding facilitated its manufacture for sale at a price less than competitive types of equipment. Manufacturing economies also can be passed along to employees in higher wages and can help to subsidize further research and engineering leading to improved refining equipment. * * *

HIGHEST NGAA AWARD GOES TO PIONEER DESIGNING ENGINEER

Henry N. Wade

The now justly famous "Hanlon Award," highest honor that can be conferred by the Natural Gasoline Association of America, and one of the greatest awards by the petroleum industry, for 1955 was awarded to one of the most outstanding pioneers in natural gasoline plant design, the first engineer to design and to aid in operating an ultra-high pressure plant — Henry N. Wade, of Hollywood, California. His contribution to the natural gasoline industry is very difficult to overevaluate.

Probably his most noteworthy achievement is the design of the United Gas Company's Alta, Louisiana, high-pressure absorption plant, the first plant to operate at 600 psi or higher. This plant was completed 'way back in 1929, when it was thought by less "plunging" minds that such pressures were hazardous, disastrous, and not to be thought of. The design pressure there was 610 psi, and the volume was 150,000,000 cu ft of raw gas per day! To care for the high percentage of fixed gases — methane, ethane, etc. — that were held in solution in the absorption oil, Wade developed the system of using several stages of "declining" weathering of pressure—a principle that has been part of all operations since that time.

When Wade's employer, J. A. Campbell Company, went out of business, he established the Parkhill-Wade Company in 1932, which continued its ventures up to 1945. This firm pioneered many improvements in the industry or collaborated in their development. During this time a working contract was in force, also, with a Denver, Colorado, firm, Stearns-Roger Manufacturing Company, to build various plants. During this period the problem of recovering more and more hydrocarbons from vapors off-wells was looming more and more importantly. Following research in the field on big-scale operating units, distillate was recovered by simple separation under temperature-pressure control. That principle, too, has become an integral part of industry technology.

With recycling of residue gas the high pressure operation really came into its own. High spot of this development was Wade's design of the now famous Katy recycling plant for Humble Oil and Refining and collaborating companies, which plant is designed for 550,000,000 cu ft per day, and returns to the formation—recycles—500,000,000 cu ft of that residue gas. By this time the pioneering work was carried on until the working pressures were 1500 to 2000 psi!

The key to all this is: Henry Wade was willing to take chances to try to prove or disprove his theories about how these things might be done. So far as we know, without exception these hard-boiled theories came through. "Where angels fear to tread" was the researching ground for a man and his cohorts willing to stake everything on their engineering, their mathematics, and their intuition.

So it is that Henry Wade receives the NGAA's Hanlon Award—the accolade of his industry. * * *

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Peter W. Sherwood
Chemical Engineer,
White Plains, New York

EXCLUSIVE

A broad outline of petrochemical operations will recognize three major categories:

1. **Conversion of Methane.** This branch, in its turn, has three important aspects:
   a. Production of chemicals via synthesis gas. This includes, above all, manufacture of ammonia and methanol.
   b. Direct conversions, leading to chlorinated methanes and hydrogen cyanide.
   c. Syntheses involving acetylene as intermediate.
2. **Production of Aromatics.** This is a relatively new task for the petrochemical industries. Benzene, toluene, and xylenes, the chief starting materials, are themselves obtained by the reforming or dehydrogenation of methyl cyclopentane, or cyclohexane and its methylated derivatives.
3. **Conversion of Aliphatic Hydrocarbons Other Than Methane.** The scope delineated by this category is self-explanatory. Actually, major importance attaches only to the derivatives of ethane, propane, and the butanes. In addition, an aliphatic C_7- fraction (heptane and heptene) serves as starting material in one commerically significant synthesis (namely, the production of iso-octyl alcohol), and a C_{12}- cut is one of the building blocks for keryl benzene.

In the two first-named categories, natural gas and petroleum fractions serve only as alternate raw materials although their impact in this field is growing most rapidly. For example, only about 60 per cent of American ammonia production in 1953-1954 is based on methane, while the remainder is manufactured from hydrogen derived from coal or from electrolysis operations. Of some 458,000,000 lb acetylene generated in 1953, only an estimated 20 per cent was obtained by methane pyrolysis. To be sure in both of these fields, the emphasis on hydrocarbon conversion has been growing rapidly in recent years (production of acetylene from this source is wholly a post-war development) and the future looks particularly bright.

Production of aromatics from petroleum hydrocarbons is also a relatively new development that supplements recovery of aromatics in coking plants. Toluene and xylene production from petroleum stocks became most important during World War II. In 1953, 74 per cent of all toluene and 91 per cent of all xylenes produced in the U.S. were derived from this source. On the other hand, benzene production from petroleum hydrocarbons did not become significant until 1950 when 5.4 per cent of the national output was so derived. By 1953, the proportion had jumped to 23 per cent.

The third major category of the petrochemical industries—conversion of aliphatic hydrocarbons—is unique in that its base stocks are obtained from petroleum sources alone, and it is to this category that the present discussion will be confined.

To be sure, many of the end products of this category are obtainable from alternate raw materials as well: Ethanol by fermentation of molasses; acetaldehyde by hydration of acetylene, etc. But the routes of synthesis that shall be considered here are based wholly on hydrocarbons derived commercially from petroleum sources only.

The Raw Materials

The U.S. Tariff Commission reports the following 1953 production volumes of hydrocarbons in the C_2-C_4 range for petrochemical purposes:

Eight reasons why Taylor

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2 ECONOMY

5 DEPENDABILITY

6 EFFICIENCY

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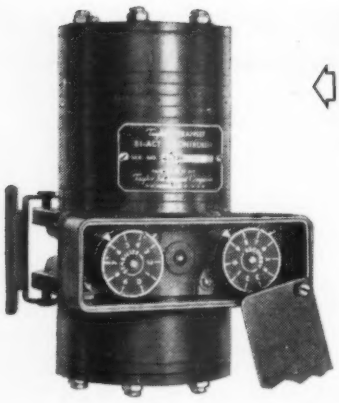

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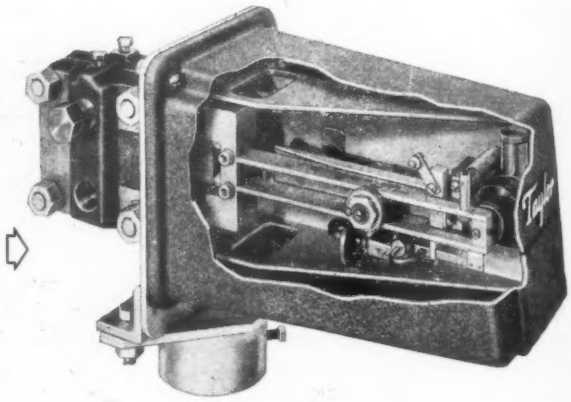
TRANSMITTERS



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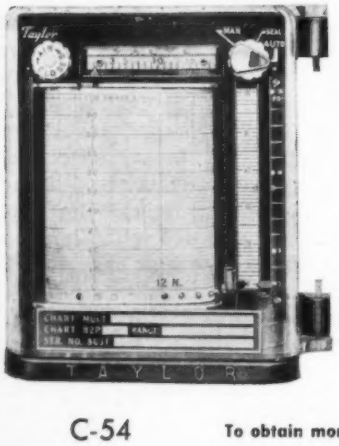

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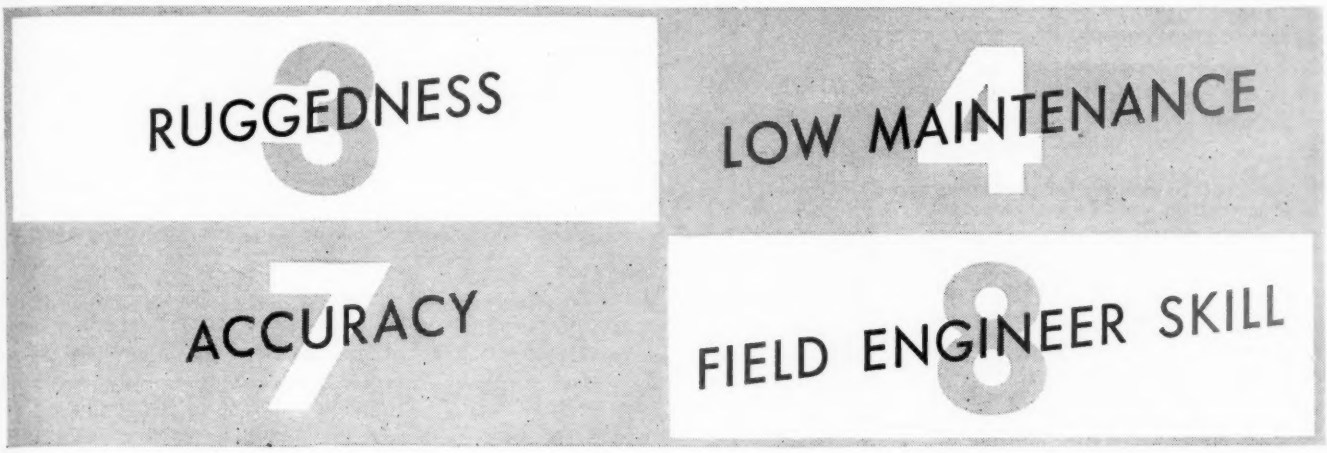

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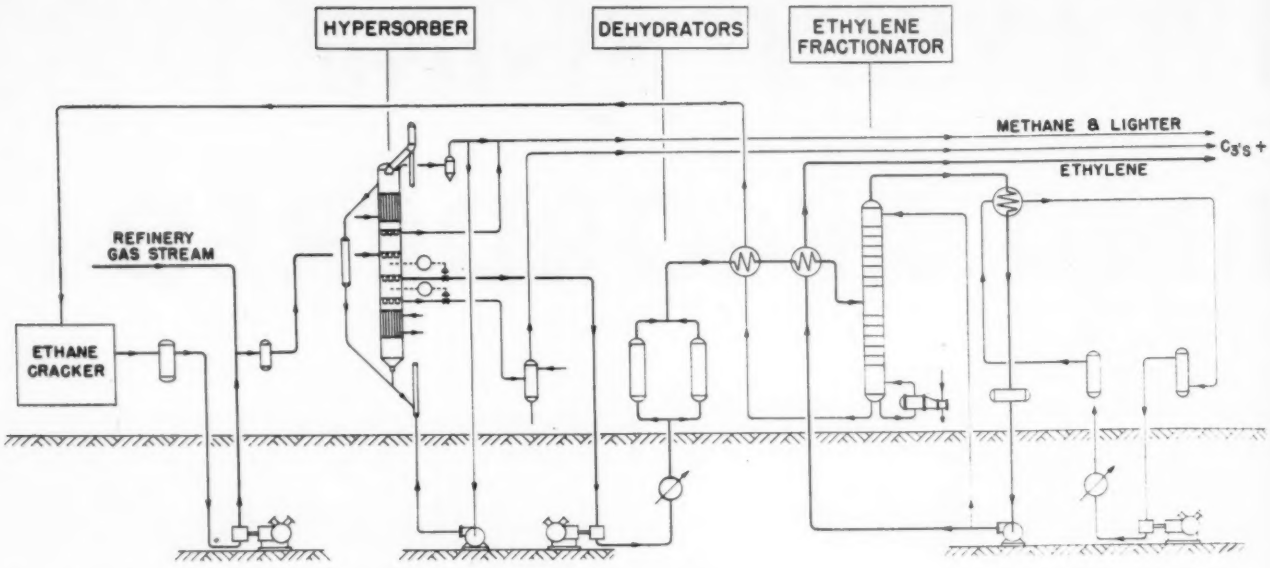


Flowchart of process for producing and purifying ethylene from refinery gas.

Ethane	144,623,000 lb
Ethylene	2,135,740,000
Propane-propylene	1,222,057,000
n-butane	388,581,000
iso-butane	97,625,000
n-butenes	906,732,000

These are not overlapping figures. E.g. ethylene derived from propane is reported only as ethylene, and the parent hydrocarbon is therefore excluded from the Tariff Commission's statistics. Nor do the data include hydrocarbons or hydrocarbon mixtures (such as LPG) which are recovered for purposes other than chemical processing.

Indeed, only a minor share of potentially available C_2-C_4 paraffins actually serve as basis for chemical syntheses. According to a recent study,[1] nearly 15 billion pounds ethylene could be produced from the 260 billion pounds cubic feet ethane recoverable yearly (at 1952 rates) from natural gas alone. Of this potential, only 3.8 per cent was realized. A more sizable percentage of recovered LPG (predominantly propane-butane) enters petrochemical processes. Thus, of 4.92 billion gallons LPG sold in 1953, an estimated 28.8 per cent served as raw material in chemical syntheses (including synthetic rubber production). This compares with chemical demand on only 8.2 per cent of LPG recovered a decade earlier.[2]

Either natural gas or by-product gases obtained in numerous refinery operations may serve as ultimate source of ethane, propane, and butane. Low-temperature fractionation serves universally for their recovery and separation. In the case of ethane, proximity of suitable hydrocarbon source usually determines the location of the chemical consumer plant. In general, this means that the installation will be near natural gas fields or major refinery operations. There are, however, two plants (at Doe Run, Kentucky, and at Tuscola, Illinois,) to which ethane is shipped by long-distance pipe line in admixture with methane. Here, too, a low-temperature fractionation plant serves to separate the desired component from the remaining gas which is then forwarded to fuel markets.

In the case of readily liquefiable propane and butane, chemical plant location is less dependent on the hydrocarbon source since transportation by barge (and often by tank car) can be achieved economically.

The great bulk of potentially available ethane, propane, and butane is found in natural gas stream, in which all three are present, declining in volume in the order stated. The amounts vary in different fields, but the following limits in composition may be taken as typical of most "wet" natural gas: Methane, 80 to 90 per cent; ethane 5 to 10 per cent; propane, 3 to 5 per cent; butanes, 1 to 2 per cent; pentanes and heavier hydrocarbons, 1 to 2 per cent.[3]

Extent to which the C_2-C_4 potential of natural gas is realized for chemical purposes has been indicated. Most of the ethane not needed for chemical purposes is retained in the natural gas for stationary fuel sales. Recovery of propane and butane is more complete to serve a number of more valuable purposes (internal combustion fuel, gas manufacture, and miscellaneous industrial applications). According to a recent survey[4] America's 455 operating natural-gasoline plants yield 9,482,813 gal per day butane and lighter hydrocarbons in the course of processing 20.4 billion cubic feet per day natural gas. This amount is supplemented by the nation's 38 operating cycling plants which recovered 2,172,000 gal butane and lighter from the daily throughput of 3.6 billion cubic feet natural gas.

The balance of C_2-C_4 hydrocarbons are obtained as by-products of refinery operations. Here, the (chemically) more useful olefins are frequently present in sufficient amount to warrant their direct and separate recovery. In general, the yield of hydrocarbon gases, and especially light olefins, obtained in any thermal or catalytic refining process rises at increasingly drastic operating conditions. Some typical compositions of by-product gas obtained in a number of refining operations[19] are given in Table 1.

TABLE. 1. Petroleum refining gases composition (Vol %).

	Mixed-phase cracking	Reforming	Vapor-phase cracking	Polyforming	Catal. cracking
Hydrogen	3	7	7	7	7
Methane	35	40	30	50	18
Ethylene	3	4	23	8	5
Ethane	20	18	12	25	9
Propylene	7	6	14	3	16
Propane	15	10	4	6	14
Isobutane	2	3	1	—	16
n-butane	8	7	2	1	5
Butenes	7	5	6	—	10
Butadienes	—	—	1	—	—

From refinery operations, also, low-temperature fractionation serves for separation of C_2-C_4 hydrocarbons. Obviously, C_3- and C_4- aliphatics are removed from the gas stream most readily. After such separation, the permanent gases contain ethylene in low concentration. This constitutes a low-cost raw material for chemical syntheses. Many reactions preclude the use of dilute ethylene, however. In that case, this olefin must be purified by one of several methods which will be described in connection with ethylene production processes.

A special situation exists in the manufacture of alcohols from refinery olefins by the liquid-phase process. In this

(Photo by Monsanto Chemical Company).

Ethylene purification towers at Monsanto's Texas City, Texas plant. In center background are styrene distillation towers.

synthesis, which shall be discussed in its proper place, a strong difference is found in the reaction affinities of propylene and ethylene. Separation of these components may, therefore, be achieved by chemical means; i.e. by first absorbing propylene in dilute sulfuric acid, and then contacting unreacted gas with concentrated acid for ethylene utilization. Sulfuric acid absorption also serves for the removal of isobutene from associated C_4-hydrocarbons in a close-boiling fraction.

The range of purity, demanded of the feedstock by the chemical-user plant, is extremely wide. Probably the most stringent requirements (among large scale operations) are set by production of polyethylene, which calls for an ethylene purity of 99.5 per cent and complete absence of acetylene. Fairly good ethylene purity (90 to 95 per cent) is also an economic requirement for production of ethylene oxide by direct oxidation, while the chlorohydrination route to this epoxide tolerates ethylene concentrations of 30 to 50 per cent (but requires absence of other olefins, hydrogen, and of acetylene). Ethyl benzene production derives certain advantages from high ethylene purity—especially if high-pressure, vapor-phase alkylation is employed. But here, too, low raw materials cost may render use of dilute ethylene economically attractive. In at least one commercial plant, benzene ethylation is carried out with olefin feedstock in 40 to 50 per cent concentration.

Production of Olefins and Isobutene

Recovery of olefins from refinery gases covers only a portion of the demand for petrochemical operations. Indeed, it has been estimated that the potential of this source, if fully realized, would cover only 20 per cent of all ethylene consumed in the United States in 1953.

Most of the needed olefins are therefore obtained by conversion of suitable paraffinic stocks. Groppe[5] estimates that of 2.2 billion pounds ethylene consumed in 1952, only 10 per cent was recovered directly from refinery gases, and 40 per cent was produced by pyrolysis of ethane extracted from natural and refinery gas. Almost the entire balance was derived by cracking of propane, with only minor quantities based on heavier feedstocks. There is a strong trend toward more extensive utilization of ethane as raw material for ethylene, a trend that will certainly be supported by the rising propane price.

There is almost no conversion of propane to propylene for its own sake. Actually, some 70 per cent of all petrochemical propane requirements are covered by direct extraction of this olefin from refinery gases. Most of the remainder is obtained as co-product in the course of cracking propane to ethylene.

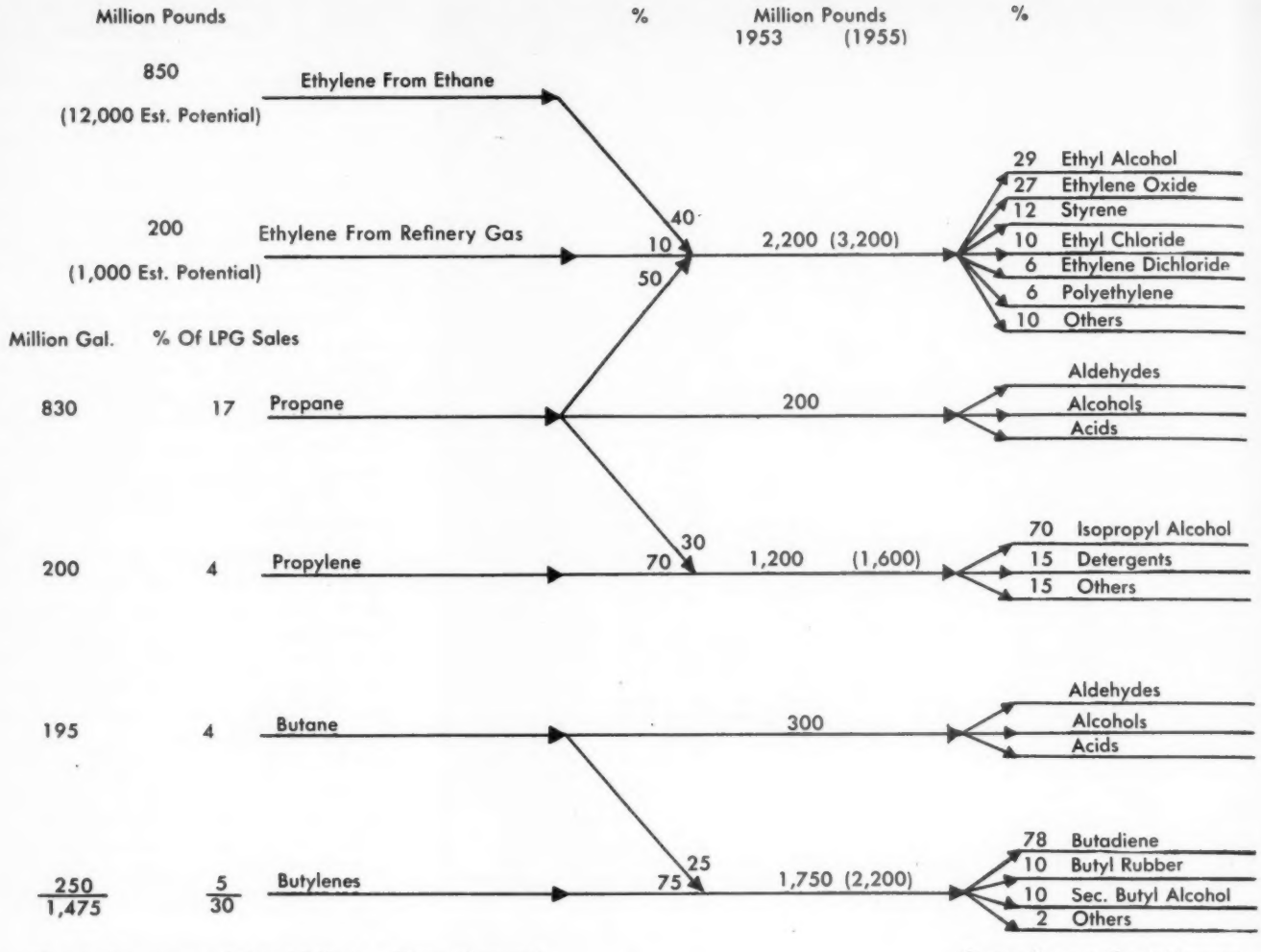
Fully three-fourths of all butenes consumed in 1953 was recovered directly from refinery gas, the balance having been derived by dehydrogenation of butane. A future shift is seen in this relation which will favor conversion of butane either to butene, or immediately to butadiene—its most important single chemical derivative. This movement is impelled by the high premium commanded by butylene (15 to 18 cents per gal vs butane at 4 cents per gal), which is largely dictated by its value in the production of alkylate gasolines.

Wholly different methods serve for the specific production of ethylene and butylene from paraffinic charge stocks. The former is obtained entirely by thermal pyrolysis, while catalytic dehydrogenation is the preferred process for production of butenes. As has been indicated, propylene is obtained in adequate amount as co-product of other cracking operations.

Processes available for the commercial manufacture of these three olefins are steadily increasing, both in number and in economic significance. A discussion of the chemical significance of C_2-C_4 hydrocarbons warrants therefore, above all, consideration of the methods that serve usefully for the large scale production of their key olefinic intermediates.

Production of Ethylene. Thermodynamically, all paraffinic, olefinic, and naphthenic hydrocarbons constitute a suitable starting material for the production of ethylene by pyrolysis. In actual practice, however, the field is greatly narrowed by economic and yield considerations, and the greater portion of America's manufactured ethylene is derived from ethane and propane.

Ethane is theoretically the ideal charging stock for the manufacture of ethylene. If carried out at suitable op-



Chemical usage of LPG in 1953, in millions of pounds.

(Courtesy Monsanto Chemical Company).

erating conditions, the dehydrogenation reaction

$$C_2H_6 \leftrightarrows C_2H_4 + H_2 \quad . \quad . \quad . \quad . \quad (1)$$

is accompanied by a minimum of primary side reactions, and yields as high as 90 per cent have been reported. Dictates of chemical equilibrium strongly favor the dehydrogenation reaction as the operating temperature is raised. It must be emphasized, however, that one cannot speak of "true equilibrium" in this connection because the primary products tend to undergo secondary pyroyltic reactions to form acetylenic and aromatic compounds, and eventually methane, carbon, and hydrogen.

As the paraffin chain of the charge stock is lengthened, an increasing number of primary pyrolytic reactions can take place, and the maximum yield of ethylene decreases accordingly. In the pyrolysis of propane, two initial reaction routes are possible, leading to ethylene and propylene, respectively:

$$CH_3 - CH_2 - CH_3 \leftrightarrows CH_2 = CH_2 + CH_4 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$CH_3 - CH_2 - CH_3 \leftrightarrows CH_3 - CH = CH_2 + H_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

It has been shown that the ratio of primary breakdown products (i.e. at reaction time extrapolated to zero) is fairly independent of operating temperature. In the case of propane pyrolysis, the relative extent of initial reactions is reflected by the following ratio:

$$\frac{\text{Methane + Propylene (Eq. 2)}}{\text{Hydrogen + Proplyene (Eq. 3)}} = .77$$

Notwithstanding the course of propane pyrolysis at its outset, the ultimate ethylene: propylene ratio rises very definitely as more drastic operating conditions (time-temperature) are chosen. This effect is due to secondary reactions, above all the cracking of product propylene to yield ethylene.

As is true in all cracking reactions, a serious engineering problem is raised by the appreciable endothermic heats of reaction involved. This consideration influences the furnace design significantly, as will be seen later. The conversion of ethane to ethylene absorbs 32,000 cal. Equation (2) requires 16,100 calories, and equation (3) calls for 32,000 cal per mole.

Controlling Process Variables in Ethylene Production. Industrial success of pyrolytic methods for the production of ethylene from other hydrocarbons rests largely on close control of the principal operating variables. The reason for this is amply evident from the large number of primary reactions which are possible, especially when some of the higher hydrocarbons are pyrolized, and from the instability of ethylene at the required cracking temperatures.

Reaction Time. At any given temperature, reaction time is the most influential variable affecting overall ethylene yield. Primary and secondary ethylene-forming reactions are opposed by ethylene breakdown. Optimum contact time will yield a pronounced maximum ethylene yield. The proper contact time is an inverse function of operating temperature and of molecular weight of the charging stock.

As might be expected, ethylene yield derived in ethane cracking shows peak value at negligible conversion (zero reaction time). Kinney and Crowley[6] have shown that up to 50 per cent conversion may be taken with 85 to 90 weight per cent ethylene yield. At 815 C, this degree of conversion is attained in 0.2 seconds. More extensive contact time causes very rapid decline in net ethylene formation. Thus, after 0.6 seconds, yield from ethane had dropped to 78 per cent, but conversion had risen to nearly 70 per cent.

Propane is substantially more susceptible to pyrolytic conversion than ethane. Indeed, the conversion of propane is quite complete after 3 to 5 seconds (815 C), while only about 95 per cent ethane can be consumed in the course of 25-30 seconds. In the case of propane cracking, however, one of primary products (namely, propylene) is itself converted to ethylene. As a result, residence period has a pronounced effect on propylene yield almost from the outset, while ethylene yield remains fairly constant at short contact times. It also declines rapidly above two seconds (815 C).

After 0.2 seconds, propane pyrolysis at 815 C yields 41 wt per cent ethylene and 25 per cent propylene. After 0.4 seconds, with 93 per cent of the propane converted, ethylene yield had risen to 45 per cent, while propylene had dropped to 14 per cent.

At installations where propylene does not serve a useful purpose, it is frequently practice to recycle this by-product to the furnace for further reduction to ethylene. Propylene is considerably more refractory than propane and yields at 0.50 seconds contact time, 30 wt per cent ethylene, with only 66 per cent total conversion.

Temperature. To a certain extent, the effect of raised temperature and of prolonged contact time is interchangeable in the production of ethylene from paraffinic stocks. Certainly, either variable may be adjusted to achieve the same degree of conversion. Kinney and Crowley[6] note, however, that at constant conversion, slightly better ethylene yields are obtainable by operating at higher temperatures.

As shown by Frolich and Wiezevich[7] ethylene yield passes through a steep maximum as the temperature is raised and the time of exposure is maintained constant. In the case of propane pyrolysis, and with a contact time of 0.4 seconds, a maximum ethylene concentration of 29.4 per cent was obtained in the reactor gases at 890 C.

Pressure. Since the primary decomposition reactions of paraffinic hydrocarbons are homogeneous and first-order, pressure has little effect on their velocity and progress. Nevertheless, operation at elevated pressures is undesirable because of the increased tendency of the primary products to undergo bimolecular condensation and polymerization reactions at the expense of ethylene yield. Commercial hydrocarbon pyrolysis for preferential ethylene production is generally carried out below 30 psi.

To lower the partial pressure of the reactants, use of various diluents, notably of steam, is not uncommon in commercial practice. The diluent can be made to serve the secondary function of supplying the necessary heat of cracking.

Catlaysts. No catalyst has so far been developed which promotes satisfactorily the dehydrogenation of ethane, or which accelerates preferentially the thermal breakdown of higher hydrocarbons to ethylene and by-products. There is evidence that some catalysts (e.g. iron-chromium oxide mixtures with various promoters) lower the required reaction temperature by as much as 200 C, without seriously affecting selectivity. Secondary decomposition reactions are generally responsible for early deactivation of such catalysts and there is a tendency on the part of such contact materials to accelerate complete breakdown (carbon formation) more significantly than the desired primary reactions.

Use of free radical reaction-initiators (e.g. dimethyl disulfide) was found to be without significant effect on ethane conversion. An increase was detected in cracking velocity of propylene by the use of such promoters.[6]

Commercial Ethylene Processes. For economic reasons, propane and ethane, alone or in mixtures, constitute the most common cracking stock for ethylene production. Ethane, which will yield substantially only ethylene and hydrogen in its primary pyrolysis, results in the least complex charge to the cracker, even where recycle operation is practiced. Its main disadvantages are its high thermal stability, necessitating very high operating temperatures, and its relative unsuitability for rail or barge shipment, which limits its use to locations having direct access to ethane by pipe line.

The use of propane as feedstock already introduces complications. Cracking products include propylene, ethylene, ethane, and methane, plus hydrogen and diverse hydrocarbons in lesser amounts. To the extent that propylene cannot be usefully employed, it is commonly recycled to the reactor where it yields additional ethylene, together with a complex mixture of by-products.

Tubular Furnaces. Most common method of cracking hydrocarbons to ethylene involves the use of two sectional tubular furnaces heated by oil or gas. In their design, outlet pressure is chosen by balancing possible yield losses due to secondary reactions at elevated pressures against the cost of recompressing the product gases. Coil outlet pressure is normally in the range 20 to 30 psi, with the lower pressure favored for a relatively unsaturated feed.

In order to maintain the wall temperature of the furnace coils within tolerable limits, high heat transfer rates from metal to process gas stream must be brought about by higher linear velocities, even at the cost of increased pressure drop through the furnace. A consideration of yields, installation, and maintenance costs leads Schutte[8] to recommend 4.5 in. as the maximum tube size to be employed.

Normal residence time varies between 0.7 and 1.3 seconds at commercial outlet temperatures between 730 and 815 C. Flexibility is given to furnace operation by varying the outlet temperature. From the principles discussed above, it is clear that raising the mean reaction temperature will tend to decrease overall yield but increase the per-pass conversion and therefore the cracker capacity.

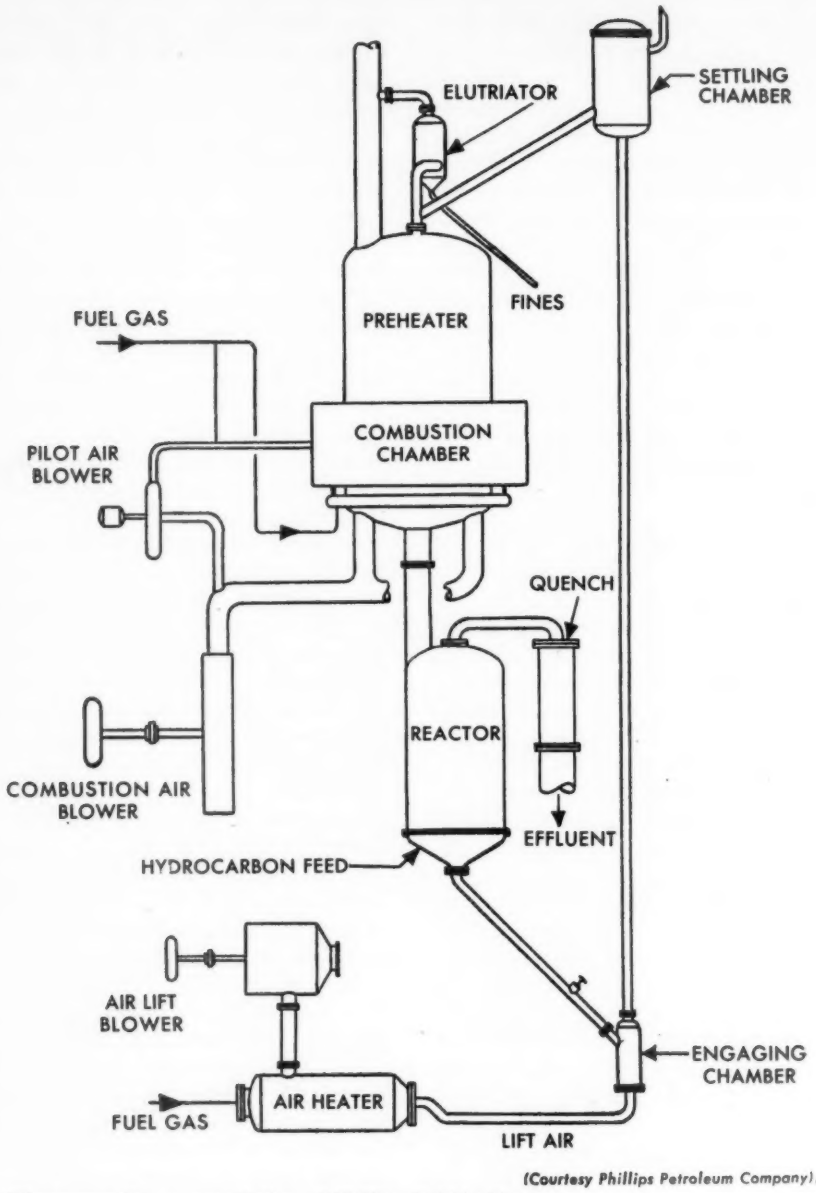
Selection of the proper tube metal is critical at the high cracking temperatures involved. Most satisfactory from the point of view of high-temperature strength are high chromium alloy steels, notably No. 310 (25/20 Cr.-Ni). Alloys low in chromium and high in nickel content must be avoided because of their tendency to promote carbon formation.

Injection of small amounts of steam with the cracking stock is recommended practice to minimize the extent of carbon deposition, and especially to reduce corrosion difficulties if sulfur is present in the feed.

As a rough rule, ultimate yields of 75 weight per cent ethylene may be obtained in the commercial cracking of ethane. Ethylene yield from propane is 40 to 50 per cent. Gas oil, which finds limited use, yields 25 to 32 per cent ethylene in commercial cracking. These typical operating figures are, of course, modified by the inverse relationship between once-through conversion and ultimate yield.

Thermofor Pyrolysis and Pebble Heaters in Ethylene Service. The major engineering problems encountered due to the high temperature, relatively high carbon formation, and sometimes corrosive conditions in the course of ethylene production, have led to the development of equipment which sidesteps the drawbacks of tubular furnaces in such service. Good performance has been reported for units in which circulating solids are employed to import needed heat to the process hydrocarbon phase.

In this category is the thermofor pyrolytic cracking process of Socony-Vacuum Oil Company. Here, the reaction unit is composed of two principal elements; a reaction chamber, and a primary heater. The hydrocarbon is introduced into the lower (reactor) chamber where it is contacted countercurrently by highly preheated pebbles. By proper adjustment of reactor vol-



(Courtesy Phillips Petroleum Company).

Diagrammatic representation of Phillips Pebble Heater.

ume, pebble level, and flow rate, it is possible to attain high-temperature time compatible with optimum cracking results. Feed may be introduced after a preheating stage or cold, in which latter case the pebbles provide not only the peak temperature heat required but the preheating functions as well.

The cracked gases leaving the reactor chamber are immediately quenched in order to minimize subsequent yield loss due to polymerization and condensation reactions. The pebbles issuing from the reactor bottom are lifted to the upper (heater) chamber where they are reheated in direct contant with burning fuel gas. Carbon, formed in the course of the reaction step, is removed from the pebbles in the heating chamber where it serves usefully as supplemental fuel.

For the thermofor pyrolysis of propane at 820 C. Eastwood and Potas[9] report ethylene formation in approximately 40 wt per cent yield together with useful propylene production of 14 per cent. The process is characterized by wide flexibility with regard to charge stock, good thermal efficiency, and avoidance of troubles due to coke obstruction.

An alternate approach to this regenerative principle is embodied in the pebble heater developed by Phillips Petroleum Company for ethylene (and acetylene) production from more highly saturated hydrocarbons. Here, too, the feed is contacted with preheated circulating pebbles. An air lift serves to raise the pebbles from the reactor outlet to the superimposed preheater chamber.

The pebble heater may serve advantageously for the simultaneous production of ethylene and acetylene. In cracking an ethane-propane mixture, Kilpatrick et al.[10] obtained peak ethylene yield at 88 per cent feed conversion. Beyond this point, acetylene yield rose precipitately, as useful ethylene formation declined. Maximum ethylene-plus-acetylene formation is encountered at 96.8 per cent conversion. At this depth of cracking, the ultimate yield is 55.2 per cent ethylene and 15.0 per cent acetylene.

Limits set by permissible metal temperature preclude the use of such high conversion in tubular furnaces. Here, the depth of cracking must be held below 80 per cent, at which conversion acetylene formation is not yet significant enough to invite commercial recovery. Use of regenerative pyrolysis equipment of the type lately developed thus, for the first time, opens up vistas of joint ethylene and acetylene production.

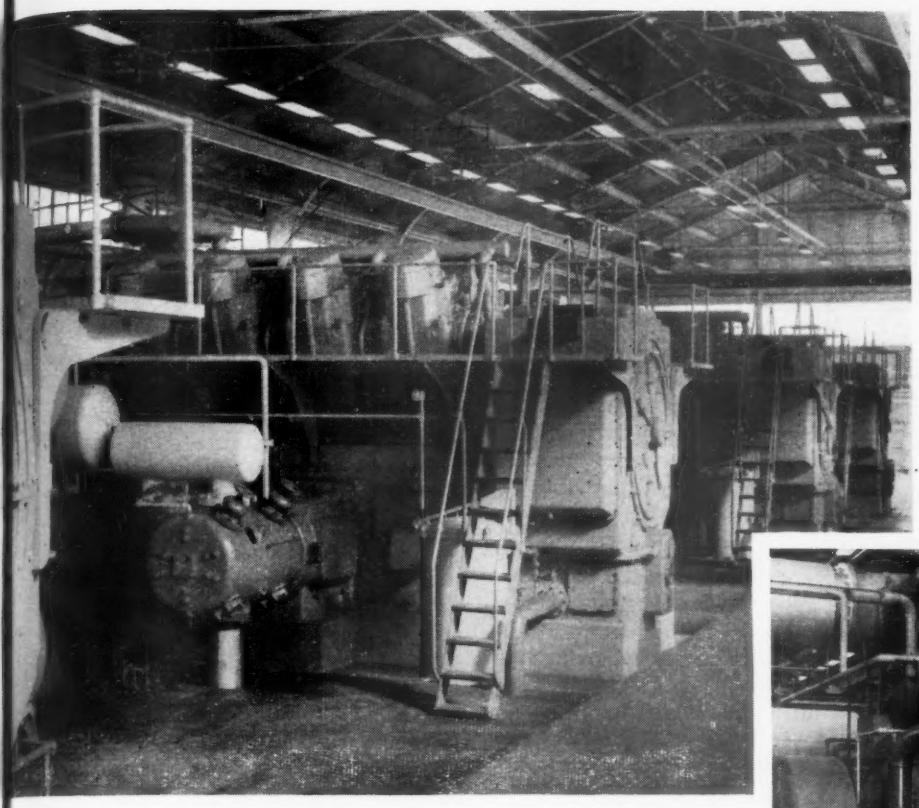
Autothermic Ethylene Processes. Ethylene production by the partial combustion of ethane is an alternative way of circumventing the engineering difficulties inherent in the construction of high-temperature tubular furnaces required for pyrolysis. Underlying principle is the thermal balancing of the endothermic cracking reaction by burning a portion of the paraffinic feedstock with admixed oxygen.

During the war years one German installation was based on such a process. I. G. Farbenwerke Leuna cracked up to 13,000 tons per year ethane by partial combustion with oxygen of Linde-Fränkl purity (about 95 per cent). The process was carried out at one-half atmosphere absolute pressure and in the presence of large ceramic surfaces that favor the preferential burning of by-product hydrogen in the presence of hydrocarbons thus raising the overall yield. Maximum cracker temperature was 885 C; ethane: oxygen ratio was 3:1. Ethylene yield of 60 to 65 mole per cent was obtained in once-through operation. The product gases contained up to 31 per cent ethylene, along with unconsumed ethane, by-product hydrogen, combustion products (11 per cent carbon monoxide, 1.5 per cent CO_2), and miscellaneous by-products in small quantities.

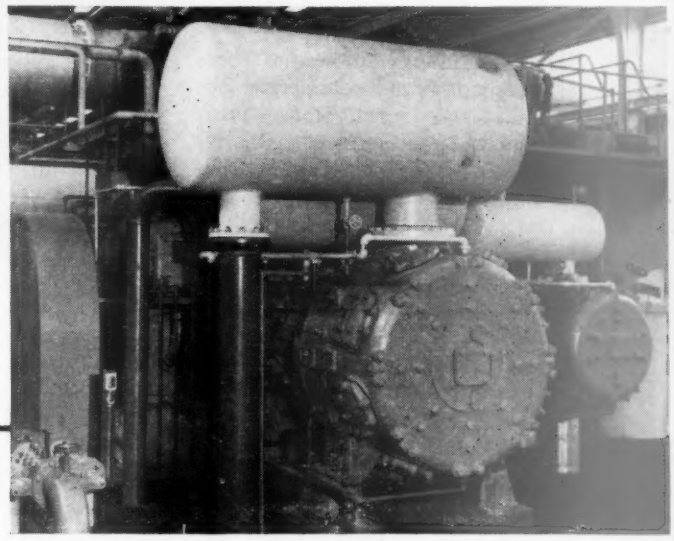
Principal objection to the process has been the need for expensive oxygen and the operating vacuum that necessitates recompression of the product gases before they can be successfully separated.

Atmospheric-Pressure Process. More recently, Universal Oil Products Company[11] has developed an atmospheric-pressure process for autothermic cracking of hydrocarbons in admixture with

Another Example of Efficient Power at Lower Cost



Shown here are the four Cooper-Bessemer compressors, rated 2000 hp at 250 rpm, in Spencer Chemical's modern Vicksburg, Mississippi ammonia plant. These 8-cylinder GMW's compress process streams such as natural gas, synthesis gas, and nitrogen.



This close-up view of a Cooper-Bessemer GMW clearly shows the neat, simple arrangement of compressor cylinders.

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air. In this, as in the German autothermic process, reaction yield depends heavily on the extent of preheat imparted to each of the feedstreams. Yield-conversion relationships follow the pattern outlined above for pyrolysis in tubular furnaces, after allowance is made for hydrocarbon consumed as fuel. A representative product gas obtained in partial air combustion of propane at 79.5 per cent conversion contains 17.7 per cent ethylene, and 5.0 per cent propylene. At 75 per cent efficiency, this degree of conversion is achieved with an oxygen: hydrocarbon mole ratio of 0.28.

Again, the high-temperature limitations imposed in tubular reactors are absent, and ethane conversions as high as 96 per cent are technically feasible (although it leads to formation of acetylene and coke at the expense of ethylene).

At this writing, autothermic processes have not found commercial application in the United States. Their advantage is largely cancelled by intensification of the purification problems, and by the consumption of valuable process hydrocarbons as fuel.

Purification of C_2- and C_3-Hydrocarbons

Commercial recovery and separation of C_2- and C_3-hydrocarbons from their different sources is accomplished by absorption, low-temperature fractionation, and hypersorption methods, alone or in various combinations.

Widest application is given to straight-temperature fractionation, and to processes combining distillation with absorptive separation. To each instance, certain preparatory treatment steps are common:

1. Sulfur Removal—Methods chosen depend on the amount and type of sulfur components present. The extent of freedom from sulfur is specified by end-use requirements and by corrosion considerations.

2. Acetylene Removal—This impurity is present in all cracker gases. Its removal may be accomplished by absorption (in acetone, acetonyl acetone, dimethyl formamide, etc.) or by catalytic hydrogenation to ethylene. For processes of the latter type, sufficient hydrogen is present in the cracked gas. The highly efficient acetylene hydrogenation processes available today require substantially complete freedom from sulfur for successful execution.

3. Gas Compression—Separation processes commonly employed for ethane-propane separation are operated at 400-600 psi. Multi-stage compression is used, whereby temperature at the outlet of each stage is limited to a maximum of 110 to 120 C to avoid polymer formation and consequent fouling of compressor valves. Higher hydrocarbons, condensed in the course of compression and after-cooling, are separated in liquid knockout pots.

4. Drying—To avoid formation of ice and gas hydrates in the course of low-temperature processing, the compressed gas must be freed of water by drying to a dew point of —75 C. This operation is normally carried out by cooling the compressed gas to 25 C and passing it over a suitable solid adsorbent such as activated bauxite, alumina, or silica gel. The adsorbent is regenerated periodically by heating with flue gases or steam.

In light hydrocarbon separation, the chief point of difference between straight low-temperature fractionation and processes involving absorption is the method selected for removing hydrogen and methane from heavier cuts. Beyond this point, distillative methods are employed.

Straight Low-Temperature Fractionation. Pressure operation is used almost exclusively for separation of light hydrocarbons. The feed gas is compressed to 550-600 psi, which is customary demethanizer pressure. With reflux temperature maintained at —90 C to —125 C (depending on operation pressure and concentration of permanent gases), the demethanizing column serves to separate hydrogen and methane from C_2-hydrocarbons and heavier components. The split is accomplished with relative ease, and provision of 25 plates in the column is normally adequate.

The dementhanized tower bottoms may be fed to an ethylene tower, in which pure ethylene is taken overhead. Alternately, a split may be taken between C_2- and C_3-hydrocarbons, and the former may be subjected to subsequent separation. The latter alternative is preferred if other components, in addition to ethylene, are to be isolated.

The deethanizer tower is generally operated at 200 to 400 psi. Using propane-propylene refrigerant, overhead temperature is run as low as —18 C. The steam-heated reboiler is run at 65 to 70 C. The C_2-fraction is separated in an ethylene tower. This purpose is accomplished at 200 to 400 psia. At the lower pressure, overhead temperature is —40 C. which calls for special steels and refrigeration by ethylene (recycled by the heat pumple principle). Propane-propylene cooling serves adequately at 400 psia with a tower top temperature of —18 C.

Separation between C_3- and C_4-hydrocarbons in the deethanizer bottoms is readily accomplished. Isolation of propylene from the C_3-fraction calls for close fractionation. Increased required reflux ratios and low separation efficiencies frequently defeat the use of pressure operation in this step.

Proplyene fractionation at 20 psi with —26 C overhead temperature for 95 propylene-propane mixture is feasible.[12] Propylene itself serves as refrigerant by air of an external heat pump cycle.

Absorption of Hypersorption in Olefin Separation. As we have indicated, an oil *absorption* step may be used in lieu of the low-temperature demethanizer tower. The crude ethylene stream is contacted with a hydrocarbon oil at 20 to 25 C and 450 to 500 psi for absorption of C_2 hydrocarbons and heavier components. At the base of the absorber column, the oil temperature is raised to 120 C of rejection of any methane and hydrogen that may also have been dissolved. The rising vapors are scrubbed with descending cold oil. Bottoms are controlled to a maximum methane content of 4 per cent (based on ethylene).

The fat oil leaving the bottom of the absorber column is passed to a stripper operated at 425 psi in which the oil is regenerated by heating it to 230 C. The overhead consists of ethylene and higher hydrocarbons that are subjected to low-temperature fractionation.

Hypersorption, a continuous countercurrent adsorption process is finding commercial application in the recovery of ethylene especially from dilute streams. Activated charcoal serves as adsorption medium. The method is used to advantage for the recovery of residual ethylene from demethanizer gas as well as for isolation of this olefin from higher-boiling hydrocarbon fractions. Ethylene recoveries of 98 per cent and product purities of 95.2 per cent (CO_2-free basis) have been reported. For a detailed description of this method of purification, the interested reader is referred to Berg's publication.[13,14]

Production of Isobutane

Isobutane is in dual demand. It is the parent hydrocarbon for isobutylene which figures prominently in the production of butyl rubber, isobutylene plastics, test-butyl alcohol, and numerous other petrochemical derivatives. Beyond that, large quantities of isobutane are consumed as alkylating stock in the production of high-octane aviation gasolines. The natural supply of i-butane from refinery gases is insufficient to meet the full demand, and

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a significant supplemental quantity is obtained by the isomerization of n-butane.

Applicable processes involve means to approach the favorable low-temperature equilibrium in the system isobutane—n-butane. At 66 C, an equilibrium mixture of butanes will contain 77.5 per cent isobutane. As the temperature is raised, the equilibrium shifts to favor presence of n-butane, so that *e.g.* at 150 C, isobutane content is only 62 C.

Unaided, equilibration at low temperature proceeds too slowly to permit commercial exploitation. On the other hand, high-temperature isomerization is unfeasible, not only because of the large required n-butane recycle ratios, but also because of the onset of cracking and other yield-consuming side reactions. Commercial processes are therefore carried out at 80 to 100 C (liquid-phase) or 120 to 150 C (vapor-phase). To accomplish conversion at reasonable rates, the reaction is accelerated by catalytic means.

Five butane isomerization processes have found important commercial application in the United States. Two of these are carried out in the vapor-phase over fixed-bed catalysts, and the others are executed in the liquid phase. All are based on the use of anhydrous aluminum chloride catalyst, promoted by dry HCl. The salt is somewhat soluble in butane and quite soluble in aluminum-hydrocarbon complex, which forms spontaneously. In the various large-scale processes, it is used either as such or in conjunction with carriers (e.g. alumina) or solvents (notably antimony trichloride).

In no case is complete per-pass conversion to isobutane taken, since isomerization rate declines markedly as the equilibrium is approached. Instead, once-through conversion is held to 35 to 45 per cent. The resulting mixture is freed of contained HCl and is fractionated. Recovered HCl and n-butane are recycled to the reactor. Ultimate i-butane yields exceeding 95 per cent of theory can be achieved in this manner.

The n-butane feedstock must be of low olefin content (max. 0.1 per cent, but preferably 0.01 per cent). The absence of sulfur is objectionable, though liquid-phase processes are somewhat more tolerant of this impurity. Presence of water must be rigorously avoided to protect the equipment from severe corrosive damage.

Salient aspects of each of five commercial butane isomerization processes may be summarized as follows:

A. Vapor-Phase Processes

1. Shell's Isocel Process uses $AlCl_3$-impregnated Porocel (a refined bauxite). Sublimed $AlCl_3$ is removed from the product stream by adsorption on alumina. Reaction may be carried out in vertical shell-and-tube converters, with the catalyst mounted in the tubes. As the catalyst ages, uniform conversion level is maintained, first by raising HCl concentration and later by boosting reactor temperature.

Commercial butane isomerization processes are capable of operation over a range of conditions that permit adjustment for maximum throughput or maximum yield as may be required by the market situation. In comparing the five processes here considered, Gunness[15] has listed in Table 2 typical operating conditions at high required throughput.

TABLE 2.

	Vapor-Phase		Liquid-Phase		
	Shell Impregnated bauxite	AIOC-Jersey Sublimed on bauxite	UOP Complex on quartz chips	Indiana-Texas Liquid complex	Shell Dissolved in $SbCl_3$
Catalyst life, gal i-butane per lb $AlCl_3$	200	200	50–120	50–120	50–120
HCl conc., wt per cent	2–14	4	5	4	5
Once-through conversion, per cent	40	35	38	38	45
Reactor conditions temp, deg C	100–150	133	95	95	82
Pressure, psi space velocity, vol/vol/hr	0.5–1.0	0.5–1.0	0.5	1.0	2.5

2. Anglo-Jersey Process catalyst is prepared by sublimation of $AlCl_3$ onto Porocel. A portion of the vaporized converted feed is introduced via a heated drum containing aluminum chloride where enough of the salt is sublimed into the stream to compensate for losses from the catalyst.

B. Liquid-Phase Processes

1. In the *UOP Process,* most of the catalyst is dissolved in $AlCl_3$-hydrocarbon complex with which the downward-flowing butanes stream is contacted in a converter filled with quartz chips. Make-up $AlCl_3$ is introduced, dissolved in a butane sidestream. The catalyst and its hydrocarbon complex are recovered from the reactor make by fractionation. The light boilers are stripped of HCl, washed, and fractionated for isobutane and (recycle) n-butane recovery.

2. Standard Oil Company of Indiana employs the same catalytic system as UOP ($AlCl_3$-hydrocarbon complex). Flow through the (hollow) reactor is in upward direction, so that only little carryover of the heavy complex occurs. After final phase separation, the make is stripped of HCl, washed, and fractionated in the usual manner. Make-up catalyst is supplied as solution in $AlCl_3$-hydrocarbon complex.

3. Shell's Liquid-Phase Process supplies catalytic $AlCl_3$ as an 8 to 12 per cent solution in antimony trichloride. Very little spent $AlCl_3$-hydrocarbon sludge is formed and this is extracted (for $AlCl_3$ recovery) by incoming n-butane. The liquid salt mixture is contacted with process hydrocarbon (approximate volume ratio 1:1) in a stirred reactor. After phase separation, dissolved catalyst components are recovered from the hydrocarbon stream by fractionation. The overhead is stripped of HCl, washed, and its components isolated by fractional distillation.

Production and Separation of Butenes

A large share of the petrochemical industries' demand for iso- and n-butene is covered by direct recovery of these components from refinery gases. Supplemental production is obtained by the catalytic dehydrogenation of the corresponding butanes.

Position of the dehydrogenation equilibrium is improved by rise in temperature. Table 3[16] shows the effect of this variable in the olefin content of butane-butene equilibrium mixtures.

TABLE 3.

	Mole % olefins in paraffin-olefin equilibrium mixture (1 atmosphere)	
Temp deg C	n-Butane	Isobutane
427	11.4	12.5
500	24.5	26.3
600	41.9	42.7
727	48.7	48.7

In practice, occurrence of cracking reactions limits the upper temperature to 600 C. In order to obtain best conversion per pass within this limitation, commercial butane dehydrogenation is carried out between 525 and 600 C. This necessitates the use of highly active and specific catalysts. Chromia-alumina is in general use for this purpose.

Effect of temperature and contact time on dehydrogenation over such a catalyst has been reported by Grosse and Ipatieff.[16] Contact time is of critical influence on conversion. At 600 C, per-pass yield of n-butylene rises from 23 per cent at 4 seconds to a maximum of 30 per cent after 2 seconds residence time. (These figures are illustrative only of trends; their numerical value is determined by catalyst formulation and age, as will be seen.)

Catalysts in butane dehydrogenation service are fouled by carbon deposition. This problem is particularly pronounced with sulfur-free feedstocks, and doping with 30 to 40 ppm has been

resorted to where pronounced soot formation actually caused obstruction to the process stream. In any event, regeneration by burning is required after one to three on-stream hours, and chromia-alumina catalysts are sufficiently rugged to permit such treatment with only tolerably slow decline in activity, provided that proper precautions are taken to restrict regeneration temperature below sintering level (700 to 750 C).

Beesley and Whipp[17] have described commercial butane dehydrogenation operations at Imperial Chemical Industries, Inc.'s Billingham, England, plant. Here, the fresh feed consists of 70 per cent isobutane and 30 per cent n-butane. Since per-pass conversion averages only 22.5 per cent, unconverted butanes are separated from the make and are returned to the conversion stage (containing about 3 per cent n-butylene). Typical recycle: charge ratio is 3.5:1.0.

The catalyst is chromia on alumina, promoted by alkali compounds for greater activity and stability. (While exact catalyst composition has not been disclosed for the Billingham plant, the writer knows of another butane dehydrogenation plant where the catalyst consists of activated alumina impregnated with 8 per cent CrO_3 and 1 to 2 percent K_2O).

With fresh catalyst, 25 per cent conversion can be attained practically at 550 C, and this is taken as the lowest economically feasible temperature. For reasons outlined above, the upper limit is set at 600 C. By operating within this range, butylene yields of 85 to 90 per cent are obtained for both iso- and n-butane.

In standard operation, one pound of butane will yield 0.85 lb butylenes, 0.03 lb hydrogen, and 0.01 lb C_1 to C_3-hydrocarbons, The remainder goes to carbon or is unaccounted loss.

Heat must be supplied to the strongly exothermic dehydrogenation reaction. At Billingham, the dehydrogenation catalyst (⅛ by ⅛-in- pellets) is provided in vertical reactor tubes that are heated by circulating flue gas. The reactors are subdivided into 4 cells, each of which contains 24 tubes, for a total of 96 tubes per converter. The tubes have an internal diameter of 2⅞ inches and are 14 feet long.

The converters are operated on a two-hour cycle.

Processing	60	minutes
Purging	1.5	"
Reactivating	58	"
Depressing and purging reactivated reactor	0.5	"

In dehydrogenation, low-pressure operation is favorable. Actual converter pressure is chosen by considerations of drop through the reactor and purification systems. The Billingham plant shows 100 psi at reactor inlet and 30 psi at the exit. Heat transfer considerations necessitate high linear flow rates through the converter tubes and account for the large pressure drop.

Starting at 550 C, the catalyst temperature is raised gradually to compensate for loss in activity. In one series of runs, 26 per cent butane conversion was maintained for 1500 stream-hours by raising the temperature from 550 to 580 C in small increments. Ultimately, the catalyst must be changed about twice per year after dehydrogenating some 2300 lb butanes per pound catalyst. Maximum-throughput operation during World War II was achieved with only one catalyst change per year by running up to higher final temperatures. This mode of operation is carried out at the cost of greater furnace wear and, of course, lower ultimate butylene yield.

Catalyst reactivation temperature must be limited to 750 C max to prevent loss of activity by sintering. It is therefore necessary to use reactivation gas containing only 2 to 3 per cent oxygen. Gas temperature at reactor inlet is 500 C. Pressure at this point is 110 psi, slightly above that maintained during conversion. This results in reactor outlet pressure of 55 psi during the regeneration phase of the cycle, and permits ready passage of the hot, spent reactivator gases through a waste-heat boiler.

The reaction-reactivation cycle to which the catalyst is subjected in butane dehydrogenation lends itself to several of the continuous process methods that serve in catalytic cracking. Modifications of TCC technique have been employed commercially.

Separation of C_4-Hydrocarbons. Quite generally, the first step in the separation of butanes-butenes mixtures is the removal of isobutene by selective absorption in sulfuric acid. The remaining mixture is fractionated into a light cut consisting of isobutane and 1-butane, and a bottoms mixture of n-butane and 2-butenes. Extractive distillation serves to separate components of these two fractions.

Extraction of isobutylene is practiced in two stages.[18] In the first stage, pre-fractionated C_4-mixture is contacted at approximately 100 F with lean extract obtained from the second stage. After phase separation the rich extract is taken to regeneration. The raffinate (hydrocarbon) phase is cooled and then enters a second extractor where it is contacted with 65 per cent sulfuric acid at 55 to 75 F. The acid layer leaving this step is forwarded to the first extraction stage. The hydrocarbons, substantially devoid of isobutylene, are worked up in a distillation scheme to be described.

Isobutylene is recovered from the sulfuric acid phase. This regeneration is effected in a tray column. Rich extract is fed at the top and live steam is introduced at the bottom. The depleted acid leaves the tower's base at 45 per cent strength, substantially free of hydrocarbon. Isobutylene is taken overhead, cooled, and washed. Some by-product tert-butyl alcohol and i-butyl polymer is liquefied in the course of isobutylene cooling. By recycling these materials to the extractor feed, isobutylene efficiency of 95 per cent may be achieved in the regeneration stage.

After isobutene separation, distillative methods serve for the purification of the remaining C_4-hydrocarbons. Straight fractionation is used to separate isobutane (relative volatility 1.47) and 1-butene rv 1.29) from n-butane and the two stereoisomers of 2-butene (rv 1.00 to 1.09). The components of each fraction may be separated by extractive distillation with furfural, which will take the purified paraffins overhead, leaving the olefins in the bottoms.

An alternate separation scheme eliminates the primary fractionation in favor of extractive distillation with acetone. This segregates the combined butenes from isobutane and n-butane. The recovered olefinic fraction may be used as feed to butadiene production without further separation.

Separation of C_4-hydrocarbons is made more complicated by the initial presence of butadiene. Techniques applicable to this situation will be considered in Part II of the present series.

Bibliography
References

1. *Chemical Engineering*, June, 1954, p. 385.
2. *Chemical Week*, June 12, 1954, p. 89-95.
3. Smith, H. M., and Holliman, U. S. Bureau of Mines I. C. 7347 (1947).
4. *Oil and Gas Journal*, April 26, 1954, p. 196, p. 212.
5. Groppe, H., Paper presented to Liquefied Petroleum Gas Association National Meeting, Chicago, Illinois, May 12, 1954.
6. Kinney, R. E., and Crowley, O. J., *Ind. Eng. Chem. 46*, 258-264 (1954).
7. Frolich, P. K., and Wiezerich, P. J., *Ind. Eng. Chem. 27*, 1055 (1935).
8. Schutt, H. C., *Chemical Engineering Progress, 43*, 103-116 (1947).
9. Eastwood, S. C., and Potas, A. E., *Petroleum Engineer*, August, 1948, pp. 43-46.
10. Kilpatrick, M. O. et al. "Phil'ips Pebble Heater." Paper presented at the forty-second annual meeting of the Western Petroleum Refiners Association, San Antonio, Texas, March 29-31, 1954.
11. Deanesly, R. M., and Watkins, C. H., "The Production of Ethylene by Autothermic Cracking." Paper presented before the American Institute of Chemical Engineers, Houston, Texas, February 26 - March 1, 1950.
12. Curtiss, E. O., *Chemistry and Industry*. August 10, 1953, pp. S 18 ff.
13. Berg, C. et al., *Oil and Gas J. 47*, April 28, 1949, pp. 95-97.
14. Berg C. et al., *Petroleum Refiner*, Nov. 1949, pp. 113-120.
15. Gunness, R. C., chapter in *Progress in Petroleum Technology*, pp. 109 ff (1951).
16. Grosse, A. V., and Ipatieff, V. N., *Ind. & Eng. Chem., 32*, 268-272 (1940).
17. Beesley, E., and Whipp, B., *Chemistry and Industry*, August 10, 1953, pp. 550-556.
18. Baumann, G. P., and Smith, M. R., *Pet. Ref.*, May, 1954, pp. 156 ff.
19. Sachanen, A. N., *Conversion of Petroleum*, 2nd ed. New York City (1948). ★ ★ ★

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Top Officers: R. E. Moore, president; W. S. Bailey, executive vice president; J. D. Watson, chief engineer.
Branch Offices: New York, N. Y., Fischbach & Moore, Inc., 226 E. 41st St., Jerome Fischbach, manager; Dallas, Texas, Fischbach & Moore of Texas, Inc., 1717 Baylor Ave., R. E. Moore, manager; Los Angeles, Calif., Fischbach & Moore, Inc., 646 N. Beachwood Dr., Allen D. Fischbach, manager; Chicago, Ill., Fischbach, Moore & Morrissey, Inc., 1009 N. Orleans, J. R. Meehan, manager; Pittsburgh, Pa., Fischbach & Moore, Inc., 81 So. 19th St., Roy Black, manager; Atlanta, Ga., Fischbach & Moore, Inc., 244 Simpson St. N.W., C. J. Kunsman, Jr., manager; Detroit, Mich., Fischbach & Moore, Inc., 101 Piquette St., Aavid A. Baer, manager; Denver, Colo., Fischbach & Moore, Inc., Mile High Center, 1700 Broadway, Jos. G. Svehla, manager; Seattle, Wash., Fischbach & Moore, Inc., 3201 Fremont; San Francisco, Calif., Fischbach & Moore, Inc., 383 Fourth St., Girard B. Rosenblatt, manager; Phoenix, Ariz., Fischbach & Moore, Inc., 3306 East Washington.
Field of Activity: Engineering, Construction.
Types of Plants: Refineries.

Fish Engineering Corp.
M & M Bldg., Houston 2, Texas.
Top Official: Ray Fish, president.
Field of Activity: Engineering.

Flint Steel Corp.
Box 1289, Tulsa, Okla.
Top Officials: C. W. Flint, Jr., chairman of board; H. G. Lewis, president; D. E. Fields, vice president.
Branch Offices: Memphis, Tenn., Bill Faulkner, manager.
Field of Activity: Design, Engineering
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

The Fluor Corp., Ltd.
2500 S. Atlantic Blvd.,
Los Angeles 22, Calif.
Top Officers: D. W. Darnell, chairman of board; J. S. Flour, president; J. R. Fluor, executive vice president.
Branch Offices: Houston, Texas, Mid-Continent Engineering, E. Moncrief, manager; Martinez, Calif., Fluor Maintenance, J. E. Winn, manager; Toronto, Canada, Fluor Corp. Ltd. of Canada, J. P. Wiseman, manager; Los Angeles, Calif., Western Area Sales, G. H. Dieter, manager; New York, N. Y., Eastern Area Sales, J. P. Kneubuhl, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Foor Engineering Co.
Box 691, Oklahoma City, Okla.

Ford, Bacon & Davis, Inc.
39 Broadway, New York 6, N. Y.
Top Officials: E. S. Coldwell, chairman and president; C. C. Whittelsey, executive vice president; R. P. Westerhoff, vice president engineering.
Branch Offices: Chicago 3, Ill., 135 S. LaSalle St., J. H. Scnultz, manager; Los Angeles 14, Calif., 606 S. Hill St., Page Golsan, manager; Toronto 1, Ont. Canada, Ford, Bacon & Davis Canada, Ltd., 44 King St. W., D. A. Uebelacker, manager.
Field of Activity: Design, Engineering, Construction.
Type of Plants: Natural Gasoline. Petrochemical.

Foster Wheeler Corp.
165 Broadway, New York 6, N. Y.
Top Officials: Admiral E. Mills, president; W. L. Martwick, vice president sales; Chas. McCulloch, vice president process plants div.
Branch Offices: Boston, Mass., A. F. Downham; Atlanta, Ga., W. D. Taulman, manager; Rochester, N. Y., H. Mault, manager; Chicago, Ill., J. Kenney, manager; Cleveland, Ohio, F. Balthaser, manager; Dallas, Texas, J. Bell, manager; Houston, Texas, D. Smith, manager; Detroit, Mich., M. F. O'Brien, manager; Kansas City, Mo., J. Taylor, manager; Los Angeles, Calif., S. Moore, manager; Philadelphia, Pa., N. A. Scott, manager; Pittsburgh, Pa., C. Russell, manager.
Field of Activity: Design, Engineering, Construction.
Type of Plants: Refineries, Petrochemical, Natural Gasoline.

Gasoline Plant Construction Corp.
208 Niels Esperson Bldg.,
Houston 2, Texas
Top Officials: M. H. Kotzebue, president; B. A. Padon, secretary and treasurer; C. L. Bryan, vice president.
Branch Offices: Corpus Christi, Texas, Fifth Floor Wilson Tower Bldg., George W. Wheeler, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Natural Gasoline, Petrochemical.

Gasoline Products Co., Inc.
15 Exchange Pl., Jersey City, N. J.

J. B. Gill Co.
P. O. Box 851, Long Beach, Calif.
Top Officials: Glen J. Gill, owner; J. B. Hiatt, chief engineer; Geo. Christen, sales manager; R. M. Allen, general superintendent.
Branch Offices: Tulsa, Okla., Oil Capitol Bldg., C. R. Hucker, manager; Calgary, Alberta, Canada, Mannix-Gill Ltd., 309 7th Ave. W., G. J. Gill, W. G. Palmer, co-managers.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline.

The Girdler Co.
A Division of National Cylinder Gas Co.
Louisville 1, Ky.
Top Officials: G. O. Boomer, president; W. R. Wood, executive vice president; O. O. Funk, secretary and treasurer.
Branch Offices: New York, N. Y., 150 Broadway, B. Storrs, manager of gas processes div.; San Francisco, Calif., 2612 Russ Bldg.; Toronto Ont., Canada,

Girdler Corp. of Canada Ltd., Suite 911, 11 Richmond St., W.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

David Gordon & Co.
82 Hickory Grove Dr., Larchmont, N. Y.
Top Officers: David Gordon, Joseph Gordon.
Field of Activity: Design, Engineering, Construction (Management only)
Type of Plants: Refineries, Natural Gasoline, Petrochemical.

Graff Engineering & Equipment Co.
P. O. Box 13152, Dallas 20, Texas
Top Officials: R. A. Graff, J. H. Crow, L. Hannon, Jr.
Field of Activity: Design, Engineering.

Graver Construction Co.
332 S. Michigan Ave., Chicago 4, Ill.

Gray Process Corp.
135 E. 42nd St., New York, N. Y.

Grebe & Doremus Process Co.
4601 Stanford, Houston 6, Texas

Hall, H. L. Corp., Ltd.
1525 Bloor St. W
Toronto, Ontario, Canada

Justin H. Haynes & Co.
701 Colorado Bldg., Denver 2, Colo.
Top Officials: Edmund Leet, Robert E. Ohman, Max P. Arnold.
Field of Activity: Engineering.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Wyatt C. Hedrick Engineering Corp.
5214 San Jacinto St., Houston, Texas
Top Officials: G. M. McGranahan, president; Wyatt C. Hedrick, vice president; D. N. McClanahan, assistant to president; E. D. Redding, assistant to president; P. E. Hall, assistant to president.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Houdry Process Corp.
1528 Walnut St., Philadelphia 2, Pa.
Field of Activity: Design.
Top Officials: C. G. Kirkbride, president; C. C. Peavy, vice president; R. C. Hackley, Jr., vice president.

Howe-Baker Corp.
547 Esperson Bldg., Houston, Texas
Top Officials: G. B. Hanson, president; Harper Black, vice president; R. J. Phillips, manager treating division; R. O. Starke, chief engineer.
Field of Activity: Design, Engineering.
Types of Plants: Refineries.

Howes & Whitaker
3219 E. Pico Blvd., Los Angeles 23, Calif.

Hudson Engineering Corp.
Box 6158, Fairview Station,
Houston, Texas

Hunt, C. H., Inc.
Benedum Trees Bldg., Pittsburgh 22, Pa.

Hydrocarbon Research, Inc.
115 Broadway, New York 6, N. Y.
Top Officials: P. C. Keith, president; E. T. Layng, vice president; F. Ringer, vice president.
Branch Offices: Trenton, N. J., Hydrocarbon Research, Inc., Box 1419; Duesseldorf, Germany, Hydrocarbon Mineraloel G.m.b.H., 1517 Furstenwall; Paris 8, France, Hydrocarbon Engineering, S.a.r.l., 44 Avenue des Champs Elysees; Aso Paulo, Brazil, 6° Andar, Sala 601, Rua Barao de Itapetininga 93, J. W. Ward, manager, Rio de Janeiro, Brazil, Sala 801, General Heitor Pedroso, Rua da Quitanda 20.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Petrochemical.

Jackson & Moreland
600 Park Square Bldg., Boston 16, Mass.
Top Officials: Frank M. Carhart, general partner; Ralph D. Booth, general partner; John R. Coffin, junior partner; Horace B. Perry, junior partner.
Branch Offices: New York, N. Y., 19 East 47th St. (for contact only).
Field of Activity: Design, Engineering, Construction (Supervision only).
Types of Plants: Refineries, Natural Gasoline, Petrochemical (steam and power facilities only for all types of plants).

Jenkins Petroleum Process Co.
20 N. Wacker Dr., Chicago, Ill.
Top Officials: C. H. Jenkins, president; A. D. Smith, vice president; J. J. McKeague, secretary and treasurer.

Johnson, A. & Co.
61 Broadway, New York, N. Y.

The M. W. Kellogg Co.
225 Broadway, New York 7, N. Y.
Top Officials: Warren L. Smith, president; G. F. Bayes, vice president; E. F. Liebrecht, vice president; R. B. Smith, vice president; R. J. Wolf, vice president.
Branch Offices: Tulsa, Okla., Palmer Hughes, manager; Houston, Texas, T. McKay, manager; Los Angeles, Calif., A. R. Chandler, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Petrochemical.

Knowles, Morris, Inc.
Park Bldg., Pittsburgh 22, Pa.

Koch Engineering Co.
335 W. Douglas, Wichita 2, Kansas

Koppers Company, Inc.
Koppers Bldg., Pittsburgh 19, Pa.
Top Officials: W. F. Munnikhuysen, chairman of board; Fred Foy, president; G. M. Carvlin, vice president and general manager.
Field of Activity: Design, Engineering, Construction.
Type of Plants: Petrochemical.

The Kuljian Corp.
1200 North Broad St., Philadelphia 21, Pa.
Top Officials: Harry A. Kiliian, president; James L. Cherry, executive vice president; Arthur H. Kuljian, vice president engineering.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Arthur D. Little, Inc.
30 Memorial Drive, Cambridge, Massachusetts
Top Officials: Earl P. Stevenson, president; Raymond Stevens, vice president; Helge Holst, treasurer.
Branch Offices: San Francisco, Christian J. Matthew, manager; Chicago, John R. Kirkpatrick, manager; New York, Howard A. Morrison, liaison.
Field of Activity: Design, Engineering, Construction, Research Consulting.
Types of Plants: Refineries, Natural Gasoline, Petrochemical, Laboratories.

Lorentz, Merle
Box 451, Elk City, Okla.

The Lummus Co.
385 Madison Ave., New York 17, N. Y.
Top Officials: J. F. Thornton, president; E. R. Smoley, vice president; J. H. Curtis, assistant to president; A. C. Grondeck, vice president (foreign); W. W. Kraft, vice president; A. H. Shulte, vice president; V. W. Smith, vice president.
Branch Offices: Houston, Texas, 2707 Weslayan Rd., C. A. Barrere, manager; Chicago 5, Ill., 600 So. Michigan Ave., F. J. McGovern, manager; New York 17, N. Y., Fabricated Piping Div., 385 Madison Ave., D. S. Ellis, manager; Montreal, Quebec, Canada, The Lummus Co. Canada Ltd., 455 Craig St., W., D. Fulton, manager; Caracas, Venezuela, S. A., Compania Anonima Venezolana, Lummus, Apartado 573, Dr. C. H. Maury, manager; London W. 1, England, Lummus Co., Ltd., Imperial House, 80 Regent St., Adm. T. Snelley, manager; Paris 1er, France, Societe Francaise des Techniques, Lummus, 100 Rue de Rivoli, M. E. Brooks, manager; The Hague, Holland, Lummus Nederland N. V., 56 Scheveningse Weg, R. E. Wise, manager; The Hague, Holland, Lummus Werkspoor Technische, Maagschappij N. V., 56 Scheveningse Weg, H. Harper, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Macco Corporation
14409 S. Paramount Blvd., Paramount, Calif.
Top Officials: John MacLeod, president and general manager; Edw. A. Pellegrin, executive vice president; John M. Sawyer, vice president and assistant general manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Arthur G. McKee & Co.
2300 Chester Ave., Cleveland, Ohio.
Top Officials: H. E. Widdell, president; Myran J. Livingston, vice president; J. C. Baird, chief engineer.
Branch Offices: Tulsa, Okla., 439 Stanolind Bldg., R. P. Mase, manager; Elizabeth, N. J., P. O. Box 512, J. A. Kraemer, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

L. A. Mekler
525 Lexington Ave., New York 17, N. Y.
Top Official: L. A. Mekler.
Field of Activity: Design.

Mellon Institute
4400 Fifth Ave., Pittsburgh, Pa.

Merritt-Chapman & Scott Corp.
260 Madison Ave., New York 16, N. Y.
Top Officials: Louis E. Wolfson, president and chairman of board; Wm. Denny, executive vice president and general manager; I. B. Purdy, vice president; E. A. Pasha, vice president.
Branch Office: Cleveland, Ohio, Great Lakes Marine & Heavy & Dredging Division, Sherman H. Serre, manager.
Field of Activity: Construction.
Type of Plants: Petrochemical.

Montgomery, J. M.
15 N. Oakland Ave., Pasadena, Calif.

Moore & Munger Co.
33 Rector St., New York, N. Y.

The C. W. Nofsinger Co.
906 Grand Ave., Kansas City 6, Mo.
Top Officials: C. W. Nofsinger, president; J. S. Rearick, engineering manager; J. P. Sherrod, office manager.
Field of Activity: Design, Engineering, Construction (Supervision).
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

James P. O'Donnell, Engineers
39 Broadway, New York 6, N. Y.
Top Officials: James P. O'Donnell, P. E. manager, John J. Lanigan, Chief P. E. engineer.
Branch Office: Beaumont, Texas, Bowie Bldg, Chas. A. Knight, manager.
Field of Activity: Design, Engineering.
Types of Plants: Refineries, Petrochemicals.

O. L. Olsen Co.
416 Pierce Ave., Houston 3, Texas.
Top Officials: O. L. Olsen, J. D. Glidden, J. A. Mulvihill.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Natural Gasoline, Petrochemical.

XUM

The Parco Company, Inc.
82 Beaver St., New York 5, N. Y.
Top Officials: J. R. Parker, president; N. M. Weisser, assistant to president; E. Esikoff, secretary and treasurer.
Branch Office: New York, N. Y., Industrial Engineers, Ltd., 122 East 42nd St., Wm. E. Jeffrey, president; J. B. Adoue, Jr., vice president; J. R. Parker, vice president.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline (Not Parco, only Industrial), Petrochemical.

Parker, Steffens & Pearce
135 S. Park, San Francisco, Calif.

Parkhill-Wade Co.
Box 6877, Los Angeles 22, Calif.

The Ralph M. Parsons Co.
Oviatt Bldg., 617 South Olive St., Los Angeles 14, Calif.
Top Officials: R. M. Parsons, president and general manager; Milton Lewis, executive vice president; V. E. Bradford, secretary and treasurer.
Branch Offices: New York, N. Y.; Washington, D. C.; Tulsa, Okla.; Ankara, Turkey; Baghdad, Iraq; Beirut, Lebanon; Karachi, Pakistan; Paris, France; New Delhi, India.

Petro-Chem Construction Company
P. O. Box 6424, Houston, Texas
Top Officials: William H. Zee, president; George Zarafonetis, vice president and chief engineer; Ed Howerth, vice president and general manager.
Branch Offices: Mexico City, Ed Howerth, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Petro-Chem Development Co., Inc.
122 East 42nd St., New York 17, N. Y.
Top Officials: John S. Wallis, president; Jack Throckmorton, vice president; T. B. Leech, general sales manager.
Branch Offices: Tulsa, Okla., Bethlehem Supply Co.; Houston, Texas, Betnlehem Supply Co.; Chicago, Ill., Faville LeVally Corp.,; Boston, Mass., Flagg, Brackett and Durgin; Pittsburgh, Pa., D. D. Foster Co.; Louisville, Ky., Gordon D. Hardin, manager; Los Angeles, Calif., Lester Oberholtz, manager; Narberth (Philadelphia), Pa., Turbex Equipment Co.
Field of Activity: Design, Engineering, Construction (all 3 for furnaces).
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Petro-Chemical Equipment Co., Inc.
6006 Harvey Wilson Dr., Houston, Texas.

Petroleum Engineering, Inc.
First National Bank Annex, Dallas, Texas.

Petroleum Rectifying Co. of Calif.
1390 E. Burnett, Long Beach, Calif.

Petreco (Div. of Petrolite Corp.)
P. O. Box 2546, Houston, Texas.
Top Officials: Dr. Chas. M. Blair, president; Gordon S. Nees, vice president; Ira S. Boydstun, sales manager.
Branch Offices: New York 17, N. Y., Chrysler Bldg., G. M. Badger, manager; Toledo, Ohio, 3025 W. Bancroft, C. Stolzenbach, manager; Fort Worth, Texas, 4924 James St., H. R. Jarvis, manager; Houston, Texas, 3202 So. Wayside Dr., J. W. Orebaugh, manager; Winnipeg, Man., Canada, 250 Elm St., W. G. Jarrell, manager; Long Beach 6, Calif., 1390 East Burnett, W. K. Mellon, manager.
Field of Activity: Design, Engineering.
Types of Plants: Refineries.

Pioneer Industrial Co.
120 Bearle St., P. O. Drawer 1232, Pasadena, Texas.
Top Officials: H. W. Finney, president; C. W. Hoffman, vice president; J. D. Sherrill, vice president.
Branch Office: Pasadena, Texas, Pioneer Industrial Co. (Ethyl Project), P. O. Box 576, Carl Putzka, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Pittsburgh Consolidated Coal Co.
(R&D Division), Library, Pa .

Podbielniak, Inc.
341 East Ohio St., Chicago 11, Ill.
Top Officials: Walter J. Podbielniak, president; W. G. Podbielniak, executive vice president; Collin M. Doyle, vice president and general manager.
Field of Activity: Design, Engineering.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Poling and Bacon Construction Co., Inc.
3503 Woodville Rd., P. O. Box 71, Sta. "A," Toledo 5, Ohio.
Top Officials: S. V. Bacon, president; Michael Susko, vice president; J. E. Biroschak, secretary.
Field of Activity: Construction.

Poole-Pritchard Ltd.
10503 109 St., Edmonton, Alberta, Canada
Top Officials: E. E. Poole, president, Edmonton, Alberta; J. F. Pritchard, vice president, Kansas City, Mo.; J. E. Poole, vice president, Edmonton, Alta.
Parent Companies: J. F. Pritchard & Co., 4625 Roanoke Parkway, Kansas City, Mo.; Poole Construction Co. Ltd., 10503 109 St., Edmonton, Alta.

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3. *To provide two-stage control by opening one circuit on a rise and a second circuit on a further rise.*

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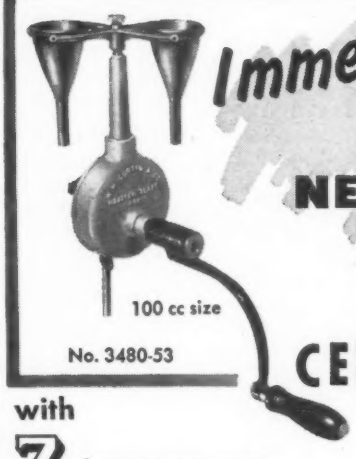

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Branch Offices: 2402 2A St. S.E., Calgary, Alta., C. A. Stollery, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Prengle, Dukler, & Crump
1010 Dennis St., Houston, Texas.
Top Officials: H. Wm. Prengle, Jr., A. E. Dukler, Joseph R. Crump.
Field of Activity: Design, Engineering.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

J. F. Pritchard & Co.
4625 Roanoke Parkway, Kansas City 12, Mo.
Top Officials: J. F. Pritchard, president; H. Arthur Martin, executive vice president; P. S. Lyon, secretary and treasurer.
Branch Office: J. F. Pritchard Co. of Calif., Karl E. Johnson, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Process Industries Engineers, Inc.
5640 Friendship Ave., Pittsburgh 6, Pa.

Process Management Co., Inc.
100 W. 10th St., Wilmington, Dela.

Procon Incorporated
1111 Mount Prospect Rd., Des Plaines, Ill.
Top Officials: C. B. Whyte, president; J. C. Reed, vice president construction; A. G. Petkus, vice president engineering.
Branch Offices: London W. C. 2, England, Procon (Great Britain) Ltd., 112 Strand, C. B. Robbins, manager; Toronto, Canada, Procon (Canada) Ltd., 40 Advance Rd., W. A. Anderson, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Reetz, William T., Inc.
Box 1254, Santa Ana, Calif.

The Refinery Construction Co.
P. O. Box 6734, Houston 5, Texas.
Top Officials: Geo. H. Zarafonetis, Ed. R. Howerth, Wm. H. Zee.
Branch Office: Houston, Texas, Petro-Chem Construction Co., P.O. Box 6424.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Refinery Engineering Co.
Wright Bldg., P. O. Box 1558, Tulsa, Okla.
Top Officials: T. M. Lumly, president; D. O. Givens, vice president and general manager; P. A. Kahle, vice president.
Branch Office: Toronto, Ont., Canada.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Geo. P. Reintjes Co.
2517-19 Jefferson St., Kansas City, Mo.
Top Officials: Geo. P. Reintjes, Jerry G. Reintjes, Patrick H. Soden.
Branch Office: New York, N. Y., 60 E. 42nd St., W. Jack Hofmann, manager.
Field of Activity: Design, Construction.
Types of Plants: Refineries.

A. J. Rife Construction Co.
Box 6725, Dallas 19, Texas.

Russell Engineering Corp.
P. O. Box 6731, 2609 Sunset Blvd., Houston 5, Texas.
Top Officials: Geo. F. Russell, president; C. E. Radic, project engineer; J. M. Hoover, office manager and purchasing agent.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

The Rust Engineering Co.
575 Sixth Ave., Pittsburgh 19, Pa.
Top Officials: S. M. Rust, Jr.; J. M. Kelley, S. W. Galloway.
Branch Offices: Birmingham, Ala., 400 Exchange Bldg., 2109 Fifth Ave., No., G. M. Rust, manager; New York, N. Y., 60 E. 42nd St., C. Dana McCoy, manager; Washington, D. C., 902 Denrike Bldg., 1010 Vermont Ave., N. W., Peyton S. Hopkins, manager.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Petrochemical.

Sachs, Albert P.
314 W. 100th St., New York, N. Y.

Salem Engineering Ltd.
1525 Bloor St., W., Toronto, Ont., Canada
Top Officials: F. E. Coombs, president; J. W. Kennedy, chief engineer; Ian Smellie, sales manager.
Field of Activity: Engineering, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Sanderson & Porter
52 Williams St., New York, N. Y.

Scientific Design Co., Inc.
Two Park Ave., New York 16, N. Y.
Top Officials: H. A. Rehnberg, president; Ralph Landau, executive vice president; Robt. B. Egbert, vice president.
Field of Activity: Design, Engineering, Construction.
Types of Plants: Petrochemical.

Selas Corporation of America
Erie Ave. and D Street, Philadephia 34, Pa.
Top Officials: F. O. Hess, president; Ed L. Fortin, vice president and treasurer; James Kniveton, vice president.
Branch Offices: Dayton 6, Ohio, 2118 Salem Ave., M. O. Kaufman, manager; Newark 2, N. J., 9 Clinton St., W. M. Smith, manager; Cleveland 6, Ohio, 12429 Cedar Rd., T. G. Thurston, manager; Los Angeles 25, Calif., 11168 Santa Monica Blvd., S. A. Whitehurst, manager; Pittsburgh 24, Pa., 3829 Willow Ave., J. L. Wilson, manager; Chicago 24, Ill., 3857 W. Washington Blvd., R. S. Van Note, manager; W. Hartford 7, Conn., 62 La Salle Rd., Rm. 207, Fred Whiteside, manager; Detroit 2, Mich., 224 Lexington Bldg., 2970 W. Grand Ave., E. D. Allen, manager; University City 24, Mo., 8643 Brookshire Lane, R. M. Breckenridge, manager; Houston 19, Texas, 2417 Dryden Rd., Box 13182, T. P. Drummond, manager; Rochester 18, N. Y., 315 Brooklawn Dr., W. C. Schneider, manager.
Field of Activity: Design, Construction.
Types of Plants: Refineries, Natural Gasoline, Petrochemical.

Sharples Chemicals, Inc.
Wyandotte, Mich.

Sharples Corporation
2323 Westmoreland St., Philadelphia, Pa.
Top Officials: P. T. Sharples, chairman of board; G. J. Keady, president; F. W. Stakelbeck, executive vice president.
Branch Offices: New York District Office, 501 Fifth Ave., New York 17, N. Y., J. T. Costigan, sales manager; Philadelphia District Office, 2300 Westmoreland St., Philadelphia 40, Pa., R. A. Armstrong, sales manager; Cleveland District Office, 453 Hippodrome Annex, Cleveland 15, Ohio, W. H. Craig, sales manager; Chicago District Office, Railway Exchange Bldg., 80 E. Jackson Blvd., Chicago 4, Ill., W. R. Prosch, sales manager; San Francisco District Office, 686 Howard St., San Francisco 5, Calif., F. J. Cygan, sales manager; Houston District Office, 1712-A Esperson Bldg., Houston 2, Texas, T. I. Kennedy, sales manager.
Field of Activity: Design, Engineering, and Construction of Centrifuges and Centrifugal Processes.
Types of Plants: Complete plants for dewaxing, acid treatment of petroleum stocks, white oil production.

Sollitt, Summer S., Construction Co.
307 N. Michigan Ave., Chicago 1, Ill.
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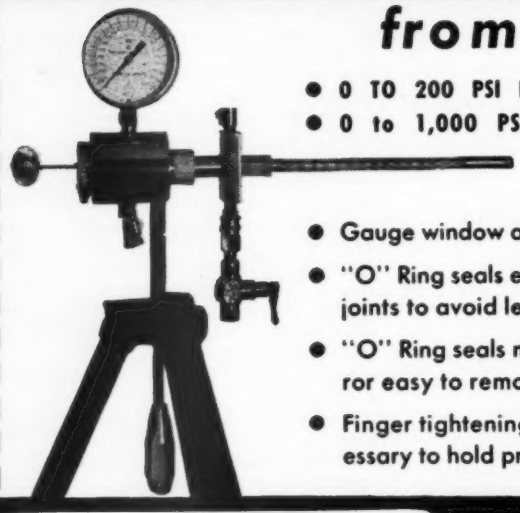

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DIRECT OXIDATION OF ETHYLENE TO ETHYLENE OXIDE

EXCLUSIVE

Ralph Landau*

ETHYLENE oxide is now produced in larger quantity in the United States than all but a few other organic chemicals, and world production now stands at approximately 1,000,000,000 lb per year. The growing volume of production has placed it in a category with such organic compounds as ethyl alcohol and phenol. Consequently, recent developments in the technology of ethylene oxide manufacture assume a vital importance.

This article will describe the commercial situation of ethylene oxide and its effect on current production techniques, particularly in two plants now operating on the basis of the new direct oxidation process developed by the author's company.

Current Industry Economics

In the fall of 1953 the price of ethylene oxide and glycol dropped because these materials became relatively plentiful for the first time since the war. By the spring of 1954, the price of ethylene oxide, in tank car lots, had fallen to approximately 13.5¢ per lb. In the summer of 1954 the price rose to 15¢ per lb. It is interesting to note that references to this price increase mention the fact that the old price was very close to the production cost. And in fact, calculations of the cost of producing ethylene oxide by the chlorhydrin process put the figure very close to 13.5¢ per lb.

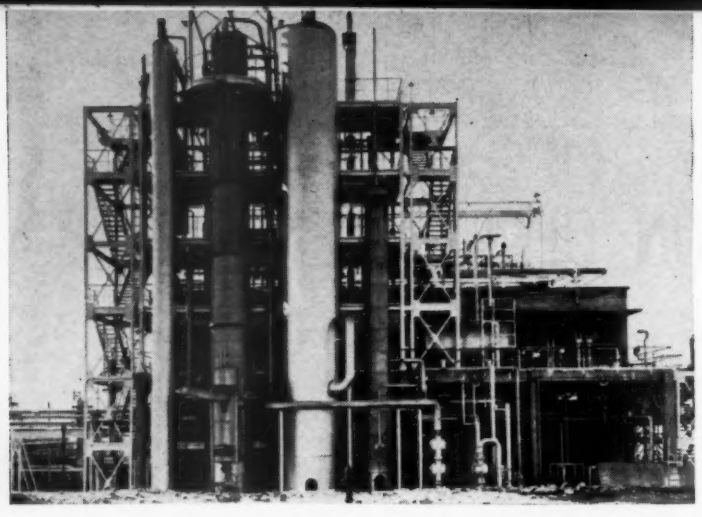
Even at present price levels, ethylene oxide is underpriced; in fact the marginal producers may be operating at close to a loss. Published accounts of the differences in production costs between the chlorhydrin process and the direct oxidation process suggest that the direct oxidation process should be able to operate with an approximate return on investment.

It may be said that the direct oxidation process has helped to make ethylene oxide one of the cheapest and most widely used chemicals in the industry. This may stimulate its use in non-ionic detergents, in ethanolamines, and in a wide variety of other uses. Current trends in motor car design, for example, are tending to increase the sales of ethylene glycol antifreeze.

History of Direct Oxidation of Ethylene

The basic discovery that ethylene could be oxidized directly over a silver catalyst was made in France by Lefort. But the first commercial application of the discovery was made not in France, but in the United States by the Carbide & Carbon Chemicals Corporation. The firm erected its first plant in 1937-1938, and is understood to have employed the process in all its plants constructed since then. Until 1953, however, all other companies producing ethylene oxide were using the chlorohydrin process, which involves indirect oxidation of ethylene with chlorine to produce ethylene chlorhydrin and its saponification to ethylene oxide.

*Scientific Design Company, Inc.



▲ FIG. 1. Plant employing the direct oxidation process, built in 1953 for Naphtachimie, in France, by Scientific Design, Inc.

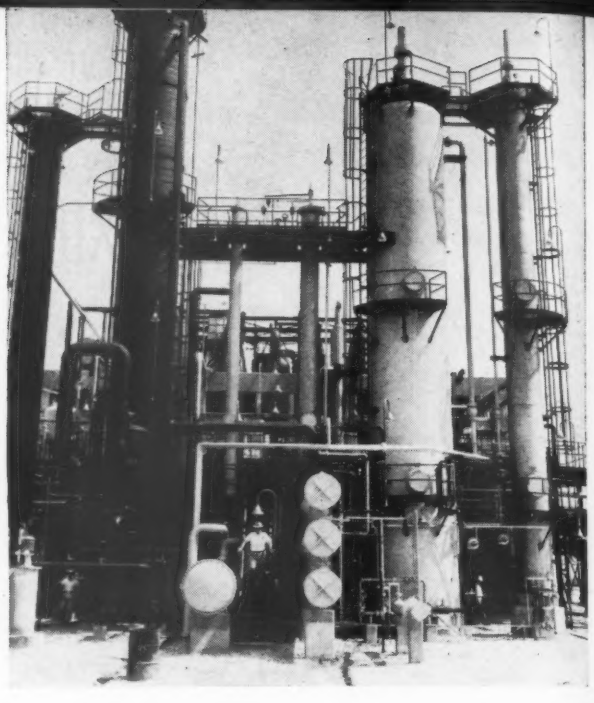


FIG. 2. Direct oxidation plant, planned by Scientific Design and put into operation by Nitrogen Division, Allied Chemical and Dye Corporation, in February, 1954 ▶

Successful commercial use of Lefort's original discovery stimulated research for improvement of the process. A number of organizations conducted research along this line, among them Du Pont, Ethyl Corporation, Monsanto, Celanese, Standard Oil of Indiana, Allied Chemical & Dye, Imperial Chemical Industries Ltd., the Distillers Company Ltd., I. G. Farben, U. S. Industrial Alcohol Company, Shell, National Research Council of Canada, Publicker Industries, and Atlantic Refining Company. None of these companies, however, used the process on a large scale.

In the summer of 1953, Naphtachimie—a French petrochemical firm organized by Pechiney, Kuhlmann, and Societe Generale pour les Huiles de Petroles (an affiliate of Anglo-Iranian Oil Company*) became the second firm to operate a successful direct oxidation plant. In addition, it was the first to use the process developed by Scientific Design Company.

In February, 1954, a second direct oxidation plant planned by Scientific Design was put into operation by the nitrogen division of Allied Chemical & Dye Corporation. A third will soon be underway by SD for the Societe Chimique des Derives du Petrole of Antwerp, Belgium, and like Naphtachimie, will use SD's own process. The performance of these plants under production conditions had established the process as a commercial reality.

The SD Process Compared With Other Processing Techniques

Decisions made by Scientific Design during development of the process were made only after extensive experimentation. Discussion of a few of the key aspects of ethylene oxide manufacture will help clarify the differences between the SD process and other processes.

1. **Air vs. Oxygen.** Some authorities indicate a preference for the use of oxygen rather than air. Obviously, if oxygen can be supplied as a by-product at no cost, it may be economical to use oxygen, and the SD process is adaptable to this mode of operation. Experience and careful studies show, however, that even under the most widely varying conditions, air is nearly always cheaper in operating cost and capital investment.

It is presumably hoped that the use of oxygen will reduce purge losses of ethylene in a recycle system, since there is no added nitrogen that would require purging. In actual practice, however, other factors more than offset this apparent advantage.

Low oxygen concentrations in the gases are necessary to avoid explosion hazards. This means that whether air or oxygen is employed large volumes of inert gases must be handled in the system. Further, an oxygen plant costs far more than the combined costs of equipment for air compression and elimination of ethylene losses in the purge system.

2. **Recycle vs. Single Pass.** The curves of selectivities (or efficiencies) vs. conversion in the ethylene oxide reactions show the selectivities to be higher at lower conversions per pass—the typical pattern of such vapor-phase oxidations. Evidently, operations at lower conversions would tend to produce higher selectivities, or percentage of ethylene which reacts to form ethylene oxide. For this reason a properly designed recycle system may produce higher yields than a single-pass system, even if it is modified to operate with several reaction stages; this is particularly true when an effective means is available for recovery of the ethylene in the purge gases, such as that developed for the SD process.

Similar results may be found in other organic oxidations, such as the formation of maleic anhydride from benzene (where other factors, however, come into play.) Furthermore, in a once-through system, where air and ethylene are mixed, there is a greater consumption of oxygen. Consequently more power is consumed, since in a recycle system oxygen is conserved. An additional danger, amply demonstrated in experimental work, lies in the fact that once-through systems of air and ethylene for production of ethylene oxide will almost certainly operate within the explosive range at some point. This is not an important factor in pilot plant equipment, but can be vital in large-scale production. Avoidance of explosive conditions in such a system makes the system very dilute, with consequent high costs in capital investment and operation.

3. **Fixed vs. Fluidized Beds.** Full information on the differences between the SD fixed bed system and systems employing fluidized beds has been published elsewhere. Commercial production reports show that temperature control is excellent in properly designed fixed bed systems, that—other things being equal—yields are higher and that the plants are simpler and require less capital investment.

4. **Atmospheric Pressure vs. Higher Pressure.** Some previous processes have been designed to function at or near atmospheric pressure. No such system has ever been in wide commercial use, probably because the capacity of

*Now British Petroleum Company, Ltd.

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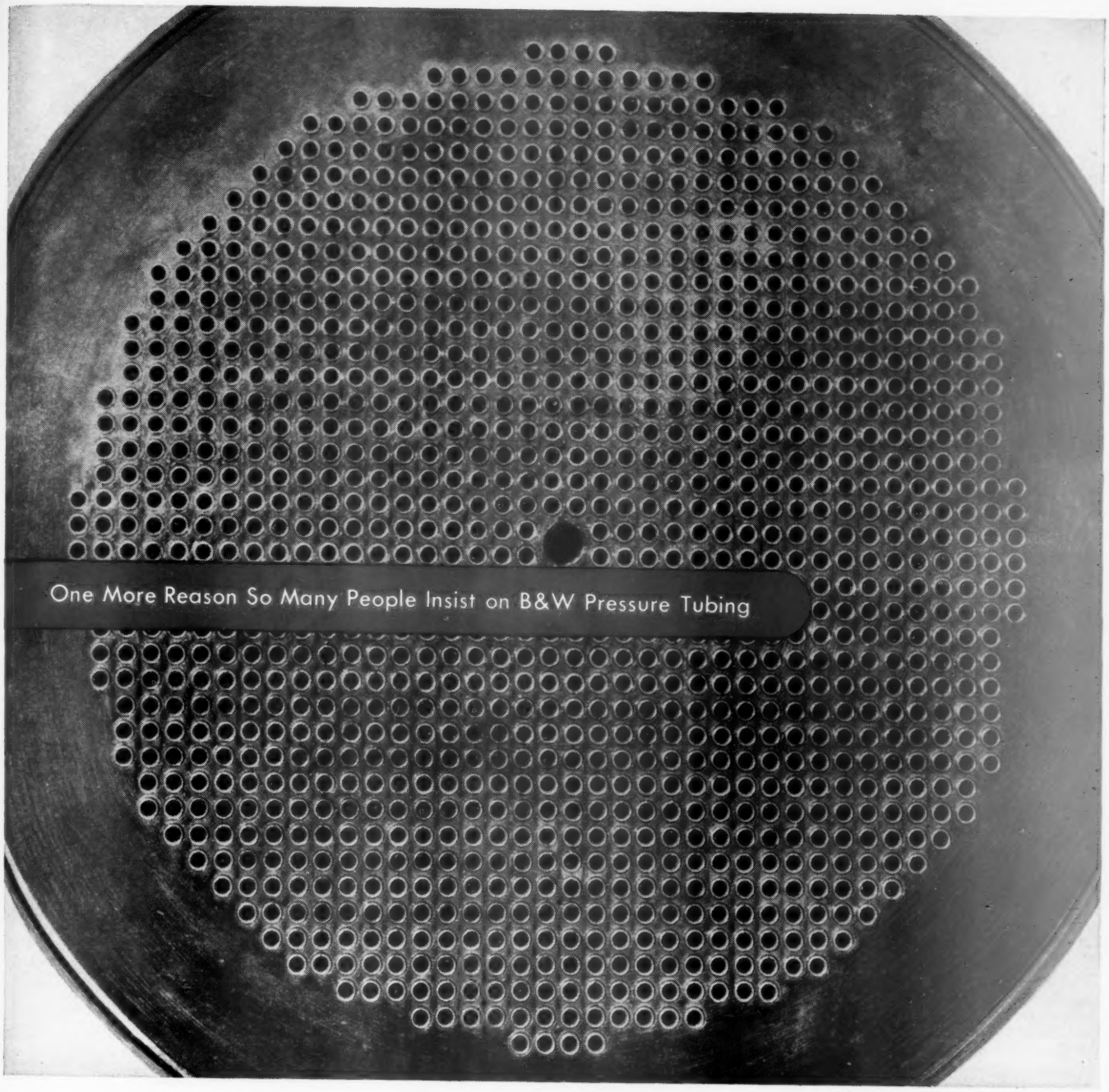

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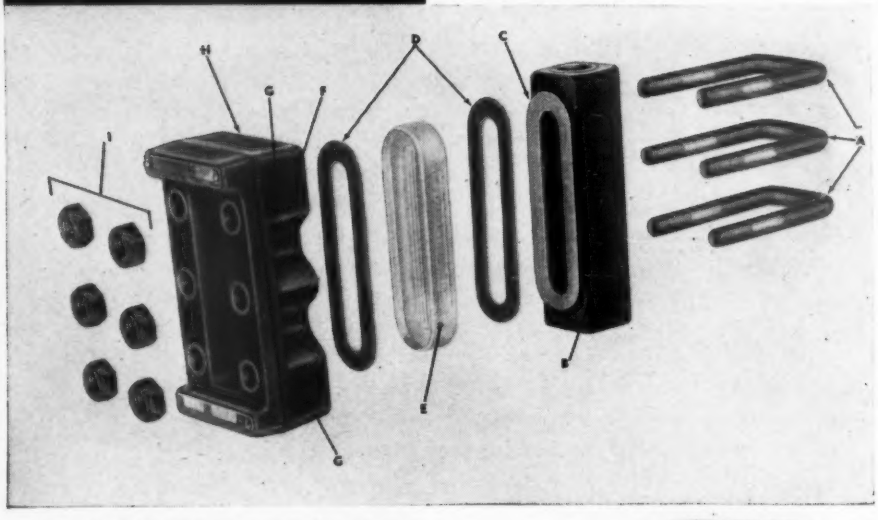

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the plant is too small per unit of capital investment, and because the recovery problems are multiplied greatly. Operations at the optimum pressure level afford improvements in these and other aspects.

In these brief explanations of the general operating conditions selected by Scientific Design for its process, it is apparent that engineering considerations play an important role in the design of a direct oxidation ethylene oxide plant. Actually, most of the research in this field has been centered on catalyst development. It is not necesary to emphasize the importance of a good catalyst, but it should be noted that engineering factors are equally important.

Performance of SD Process

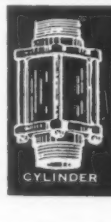
Seven years of pilot plant operation and the operation of two commerical plants have produced some conclusions regarding the process itself. It should be understood that the two plants differ in some respects; consequently these statements are of a general nature.

1. **Yields.** Some reports of yields of ethylene oxide from ethylene have been in the range of 55-58 per cent of theoretical. Reports on the SD process, on the other hand, indicate yields of well over 60 per cent. These yields, obtained not in a pilot plant but on a commercial scale, are due to factors such as improved catalyst, design of reaction system, and choice of construction materials.

2. **Purity.** Careful control of construction materials, proper design, and proper catalyst composition combine to achieve a very high degree of purity in oxide produced by the SD process, higher than that attained in the chlorhydrin process. This is increasingly important in the manufacture of detergents and other ethylene oxide derivatives, where color, chlorine content, etc., are dependent on the purity of the the ethylene oxide.

3. **Power Consumption.** Power consumption in the SD process is apparently below published figures for other processes. While power costs do not figure largely in production costs of ethylene oxide, generally accounting for less than 10 per cent of such costs, it is, nevertheless, important in investment in off-site facilities.

4. **Corrosion.** Construction materials in both plants were selected with a view to avoiding corrosion and no



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significant amount has been found.

5. **Catalyst.** Since it is always difficut to translate laboratory preparations into large-scale manufacturing operations, the SD catalyst went through a number of development stages before achieving uniformity as well as low cost of manufacture. Pilot facilities were used in development of the catalyst, and a catalyst manufacturing plant was designed for Naphtachimie, which produced a highly successful commercial catalyst.

6. **Recovery of Oxide.** The greater part of the oxide made in the SD process is recovered as ethylene oxide, and can be utilized as such or converted to glycol. Less than 1 per cent of the crude oxide is lost in recovery of refined oxide from the reaction gases.

7. **Investment.** Many estimates have been made of the capital required for an ethylene oxide plant, usually within battery limits only, i.e., the process plant proper. Such estimates, pertaining to a plant producing about 40,000,000 lb per year, are usually about 10 to 11 cents per annual pound, although some are higher. A careful examination of the actual investment cost of the two plants using the SD process and current design modifications shows initial investment in this type of plant to be less than that for a plant using any other process. Even plants of less than 40,000,000 lb capacity would require investment below 10 cents per pound.

Although the record shows that actual costs of the two SD plants were very close to the original estimates, improvements inspired by past experience indicate that new plants could be built for less money.

Conclusion

Continuing development of the process, based on actual plant experience, is stressing improvements from the commercial viewpoint. It is anticipated that increased use of ethylene oxide and glycol, stimulated by both technological and economic changes, will lead to expansion of the world's productive facilities. * * *

April Motor Fuels Show Fractional Octane Number Gains

PRACTICALLY all motor fuels covered in the Du Pont, April, 1955, survey show fractional octane number gains in city averages. As to TEL (tetraethyllead) content, 34 of the 48 cities surveyed show small drops in lead used in January samples, as compared to last October, and an increase in April as compared to January. Of the remaining 14, nearly all showed a gradual decline in TEL content from October to April. The trend is essentially the same for both fuels.

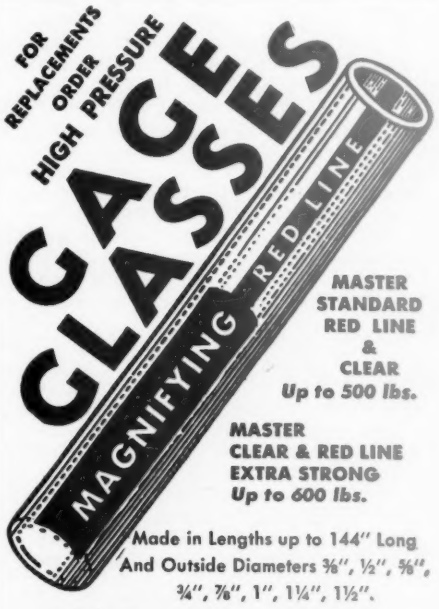
Again Calgary, Alberta, shows the lowest octane ratings, both Motor and Research, for premium fuels, 81.6 and 89.9, respectively. Salt Lake City shows the lowest ratings for regular, by both methods, Motor, 78.7, Research, 81.6.

Highest average for premium fuels by the Motor method was found in Atlanta, Georgia, 86.5; the Research high, 96.9, was at Houston, Texas. High Motor method average, 83.7 MM, was at Philadelphia. Boston showed highest regular grade Research rating, 90.4.

TEL content average was lowest for both regular and premium fuels at Winnipeg, Manitoba, 1.09 cc for regular, and 1.03 cc for premium fuels. Highest TEL content average for premium, 2.88, was at Bakersfield, California. New Orleans, Louisiana, showed the highest TEL content average for regular fuels, 2.63 cc.

Du Pont gasoline survey for April, 1955.

	Premium			Regular		
	Octane number		TEL content	Octane number		TEL content
	Motor	Research	cc/gal	Motor	Research	cc/gal
Aberdeen, South Dakota	84.0	91.3	2.14	80.5	84.8	1.67
Amarillo, Texas	84.4	93.0	2.16	79.9	84.4	1.62
Atlanta, Georgia	86.5	95.8	2.18	82.7	87.5	2.36
Bakersfield, California	85.7	63.2	2.88	79.7	83.8	1.77
Baltimore, Maryland	86.0	96.6	2.64	83.6	90.0	1.97
Boston, Massachusetts	84.8	96.1	2.20	83.4	90.4	2.17
Calgary, Alberta	81.6	89.9	2.86	78.5	83.1	2.24
Casper, Wyoming	83.0	90.4	1.62	78.6	83.7	1.17
Charlotte, North Carolina	85.8	96.0	2.25	82.6	88.5	2.40
Chicago, Illinois	85.3	93.9	2.53	81.1	85.6	1.95
Cincinnati, Ohio	84.9	94.7	2.65	82.9	89.0	2.31
Cleveland, Ohio	85.1	94.7	2.30	82.3	89.2	1.79
Columbus, Ohio	85.1	94.3	2.43	82.3	89.2	1.83
Corpus Christi, Texas	86.4	96.5	2.73	82.7	86.7	2.07
Dallas—Fort Worth, Texas	84.8	96.4	2.41	81.4	86.5	2.37
Denver, Colorado	82.0	90.4	1.53	78.8	84.1	1.34
Detroit, Michigan	84.9	94.6	2.13	82.3	88.8	1.95
Edmonton, Alberta	82.4	90.1	1.95	79.2	83.8	1.65
El Paso, Texas	84.4	92.7	1.74	79.4	82.3	1.48
Great Falls—Billings, Montana	83.3	93.2	2.19	79.4	86.3	1.68
Houston, Texas	86.2	96.9	2.72	82.9	87.1	2.55
Indianapolis, Indiana	85.0	93.9	2.30	80.5	85.7	1.84
Jacksonville, Florida	86.3	96.0	2.30	83.1	89.6	2.34
Kansas City, Missouri	84.0	92.8	2.35	79.6	84.5	1.95
Little Rock, Arkansas	86.0	96.3	2.76	82.5	87.5	2.52
Los Angles, California	84.0	94.7	2.47	78.8	84.8	1.66
Louisville, Kentucky	85.2	95.4	2.75	82.2	87.7	2.60
Memphis, Tennessee	85.6	95.7	2.71	81.6	87.5	2.34
Milwaukee, Wisconsin	86.1	94.8	2.44	80.8	85.6	1.78
Minneapolis, Minnesota	83.9	92.5	2.09	80.4	85.0	1.73
Montreal, Quebec	82.9	92.7	1.85	82.0	89.1	1.05
Nashville, Tennessee	84.8	96.0	2.61	81.9	88.0	1.37
New Orleans, Louisiana	85.8	96.3	2.81	82.2	87.7	2.63
New York, N. Y. (Metropolitan Area)	85.6	96.1	2.39	83.6	89.8	2.24
Omaha, Nebraska	83.5	92.2	2.35	80.2	85.0	2.04
Philadelphia, Pennsylvania	86.0	96.5	2.08	83.7	90.2	2.24
Pittsburgh, Pennsylvania	85.8	96.0	2.32	83.5	89.7	2.47
St. Louis, Missouri	85.0	93.6	2.42	81.2	85.9	2.12
Salt Lake City, Utah	82.7	90.1	1.33	78.7	81.6	1.72
San Francisco, California	84.5	94.5	2.20	79.0	85.0	1.20
Seattle, Washington	84.7	94.2	2.49	79.8	85.5	1.54
Shreveport, Louisiana	85.1	95.9	2.66	82.4	87.5	2.54
Spokane, Washington	83.9	94.0	2.04	78.8	84.4	1.30
Toronto, Ontario	83.8	93.8	2.08	82.0	88.4	1.32
Tulsa—Oklahoma City, Oklahoma	85.0	93.0	2.48	81.1	85.6	2.07
Vancouver, British Columbia	83.5	92.7	2.51	80.6	84.6	1.92
Wichita, Kansas	84.5	92.1	2.18	81.4	84.6	1.94
Winnipeg, Manitoba	81.9	92.1	1.03	79.9	86.0	1.09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GAGE GLASSES
MAGNIFYING
RED LINE
MASTER STANDARD RED LINE & CLEAR Up to 500 lbs.
MASTER CLEAR & RED LINE EXTRA STRONG Up to 600 lbs.
Made in Lengths up to 144" Long
And Outside Diameters ⅜", ½", ⅝", ¾", ⅞", 1", 1⅛", 1½".
High Pressure Composition
ERNST RUBBER GASKETS
All sizes to fit your gages and valves
FIG. 21—Lip Mold
FIG. 22—Standard
ERNST WATER COLUMN & GAGE CO.
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LIVINGSTON, N. J.

REFINING AND PETROCHEMICAL

PERSONALS

J. E. Miller

P. W. Cornell

▸ **P. W. Cornell,** a director of Gulf Oil Corporation since 1953, was recently elected vice president in charge of operations, engineering and development, and **J. E. Miller** was named general sales manager. A graduate of Rensselaer Polytechnic Institute, Cornell started with Gulf in 1941 as a process engineer in the engineering and construction department. In 1948 he was named staff assistant in the executive department and in 1953 joined the newly formed petrochemical activities group as assistant manager and served in that capacity until he joined the chemical department.

Miller was graduated from Wooster, Ohio, College, joined The B. F. Goodrich Company in Akron as a production worker. He held various supervisory jobs until, in 1942, he was transferred to the Goodrich-operated Lone Star Ordnance Plant at Texarkana, Texas, as auxiliary loading superintendent. In 1943 he was named production engineer at the Port Neches, Texas, Synthetic Rubber Plant, operated for the government by The B. F. Goodrich Chemical Company. From 1945 until 1952, he was plant manager there.

▸ **Robert F. Duncan** has been elevated to executive vice president and treasurer of Calumet Refining Company, and **Herbert E. Semerau** is new vice president in charge of sales. Duncan has been with the company since 1931 and Semerau started in 1930.

▸ **Eldon R. Armstrong,** research associate at the Technical Service Department of Socony-Vacuum Oil Company, Inc., was awarded a patent on continuous grease manufacture by the U. S. Patent Office recently. The award was made in conjunction with the current Patent Office exhibit on "Research and Progress in Chemistry under the American Patent System." Socony-Vacuum is one of the exhibitors.

▸ A number of management promotions in Phillips Chemical Company, wholly owned subsidiary of Phillips Petroleum Company, have been announced.

W. C. Hewitt was promoted to assistant general manager of the chemical company under **T. L. Cubbage,** vice president and general manager. **A. J. Head** became director of the manufacturing division, in charge of all the chemical subsidiary's plant operations. **A. B. Leonard** was assigned the new position of director of the rubber chemicals division, responsible for butadiene, rubber and carbon black sales. **G. H. Short** was advanced to replace Leonard as Plains plant superintendent. **H. E. Haltom** becomes Philblack plant superintendent, at Borger.

H. D. Trotter transferred to Plains plant as assistant plant superintendent. **C. M. Tucker** was moved up to manufacturing superintendent; he was succeeded as process superintendent by **L. J. Ronayne.** At the Adams Terminal site, Pasadena, Texas, **W. R. Pittman** replaced Haltom as superintendent of terminaling operations, and **G. K. Young** became mechanical and maintenance superintendent. **Earl Geoffrey** replaced Young as maintenance supervisor.

▸ **John A. Scott** has been elected president of Sinclair Chemicals, Inc., it was announced by the company. He has been executive vice president and a director of Sinclair Chemicals since its organization in 1952 and a member of the Sinclair organization since 1934. He has held a number of important research positions and from 1945 to 1951 served as assistant to the vice president in charge of Research and Development in New York. When the Petrochemicals division of Sinclair Refining Company was formed in 1951, he was named manager of the division, advancing to his recent position with the establishment of the petrochemicals subsidiary of Sinclair Oil Corporation a year later. He serves also as a director of Sinclair Research Laboratories, and of Calumet Nitrogen Products Company.

John A. Scott

M. Voogd

▸ **M. Voogd** has been named to head the combined butadiene-styrene-copolymer facilities recently acquired, through purchase from the federal government, by the Shell Chemical Corporation. **G. S. Williamson** has been named superintendent under Voogd. Both Voogd and Williamson held the same titles at the formerly government-owned butadiene plant located in Los Angeles.

▸ Bellaire Laboratories, research division of The Texas Company's producing department, has announced promotions of **B. D. Lee** and **K. C. tenBrink** to assistant directors of research and **A. S. McKay** and **J. C. Allen** as assistants to the director of research. Lee, who was assistant director, geophysical research, joined The Texas Company in 1932. He is a graduate of Texas A&M. tenBrink came with the company in 1947 after receiving a Ph.D degree from Rice Institute in 1940. McKay received his bachelor and master's degrees from the University of Saskatchewan and his Ph.D. from Cornell and joined Texas Company in 1949. Allen came with the company in 1946 after being graduated from Centenary College.

▸ **Dan M. Krausse** has been promoted to manager of manufacturing, of Cosden Petroleum Corporation. The principal manufacturing operation of Cosden is a 30,000 bbl-per-day refinery at Big Spring, Texas. Krausse joined Cosden in 1949 as control engineer and has been assistant to R. L. Tollett, Cosden president, since 1952. He is a graduate of the University of Texas, and before joining Cosden was with Sinclair Refining Company in the research and development department.

Dan M. Krausse

▸ **Paul E. Kuhl,** assistant general manager of manufacturing of the Esso Standard Oil Company, has been named general manager of the Abadan Refinery on a two-year loan assignment to the Iranian Oil Refining Company. Kuhl, a graduate of the University of Pittsburgh, joined Esso in 1926 and had been assistant superintendent of the Aruba Refinery, associate manager of Standard Oil Development's process division, and assistant manager of East Coast Manufacturing.

▸ **Richard L. Brown** has joined Yapuncich-Sanderson Laboratories, Billings, Montana. Brown is a graduate of the University of Wyoming and was formerly manager of Darrell W. Smith Company, engineering division, Midland, Texas. Firm name has been changed to Yapuncich, Sanderson & Brown Laboratories.

▸ **John P. Peet** has been advanced to senior research chemical engineer in Research and Development division at Humble Oil and Refining Company's Baytown, Texas, refinery. Upon graduation from Rice Institute in 1948, he joined research and development division.

W. K. Robbins has been promoted to senior chemical engineer in technical service division at the refinery. He was educated at Texas University, and joined Humble in 1930. He designed many pieces of equipment used in treating at Baytown refinery, and has developed odor testing procedures and trained personnel for this testing.

J. Raymond Martin is advanced to general foreman of the instrument department at Baytown refinery. He is a graduate of Rice Institute, and before his promotion was assistant instrument foreman, and general instrument foreman.

▸ **Jack C. Dart,** manager of research and development of Houdry Process Corporation, has been elected a member of the board of directors. Dart joined the corporation in 1947 as director of development at the Houdry Laboratories in Linwood, Pennsylvania. He holds degrees from Albion College and the University of Michigan, is the author of several papers on catalytic processing, and holds patents in alkylation, hydrocarbon synthesis and catalytic cracking of petroleum fractions.

He is an outstanding member of the American Chemical Society, the American Society for Engineering Education, and for eight years was a member of the National Program Committee of the American Institute of Chemical Engineers. Prior to joining Houdry, Dart was an instructor in chemical engineering at Texas A&M, and had been associated with Pan American Refining Corporation, the Magnolia Petroleum Company and Esso Laboratories.

Conversion to products service of 1168 miles of the wartime "Little Inch" pipe line by Texas Eastern Transmission Corporation, now being used to transport gas, has been given approval by a Federal Power Commission examiner. New facilities to continue the gas service now provided by the line also received approval. Provided no review is initiated, the decision on the $86,000,000 project would become a final commission order in early May. The 1168-mile 20-in. segment to be retired is between Baytown, Texas, and Moundsville, West Virginia. Cost is estimated at approximately $15,000,000 for the conversion project. New facilities to be constructed would include a 481-mile, 24-in. line from Beaumont, Texas, to connect with the firm's 30-in. line originating at Kosciusko, Mississippi. These new facilities would cost $71,000,000.

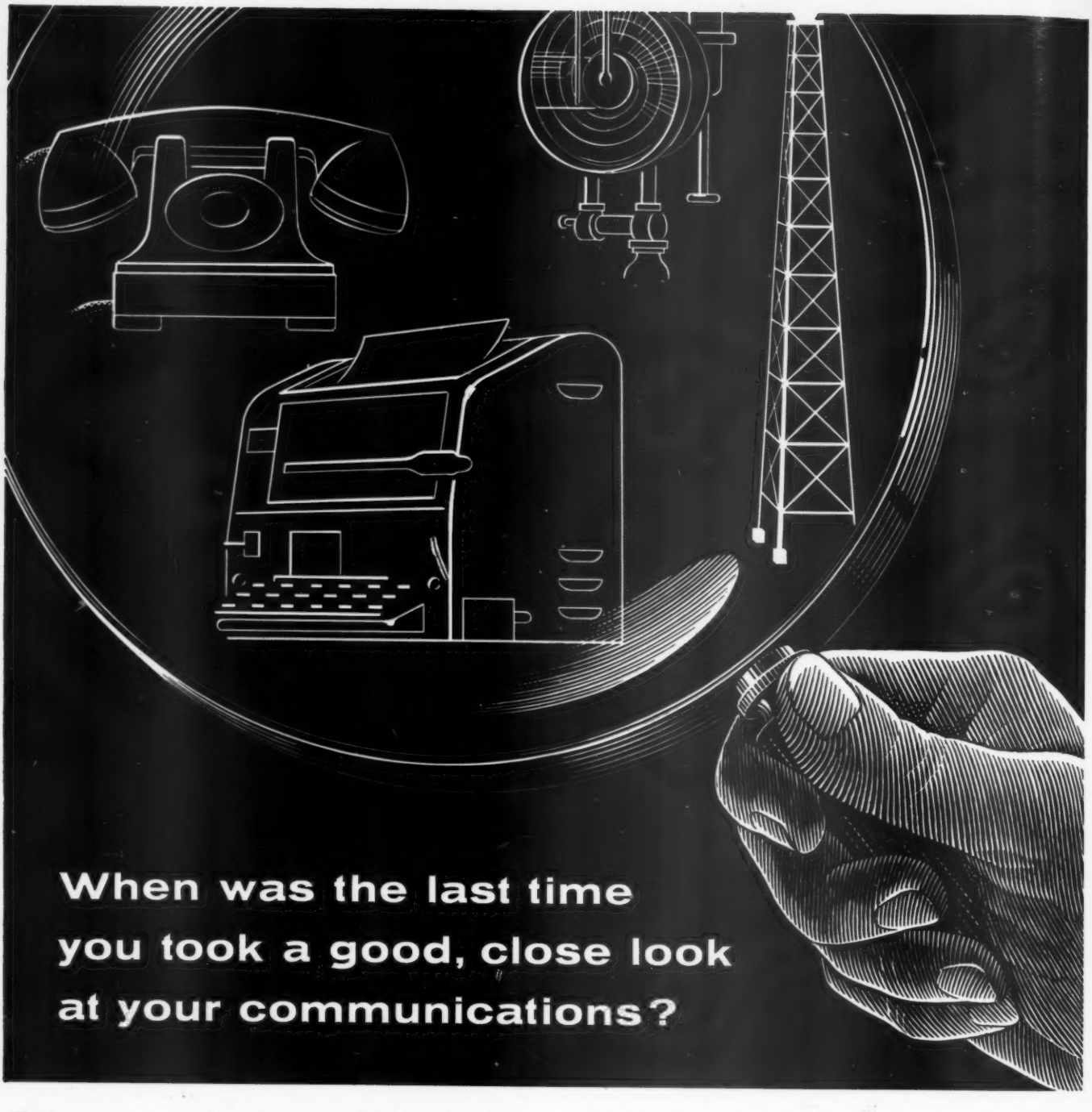
Construction is expected to get underway in May on the 445-mile Butte Pipe Line Company line in eastern Montana and Wyoming. The Butte company has been formed and will be owned by Shell Oil Company, Placid Oil Company, and Murphy Corporation. Shell Pipe Line will construct and operate the line as agent for the owners. J. K. Alfred, of Shell Pipe Line Corporation, has been named superintendent of construction on the project, including line, pump stations, and related facilities. The 10, 12, and 16-in. crude carrier will extend from near Poplar, Montana, southerly to terminals at Guernsey and Fort Laramie, Wyoming. The new link will provide transportation to Chicago and Wood River, Illinois, through connections with Platte Pipe Line at Guernsey and with Service Pipe Line at Fort Laramie.

An important step toward getting construction of the Pacific Pipe Line project underway was reached in April by an agreement between that firm and Trans-Northwest Gas, Inc. Result of the agreement is for Pacific Northwest to buy certain assets of Trans-Northwest, which in turn will drop its court appeal of the FPC decision allowing Pacific Northwest to import natural gas into the area. Westcoast Transmission Company, which had sought to import Canadian gas along with Trans-Northwest, was also a party to the agreement. Trans-Northwest will surrender pipe line franchises and cooperate in preparing the area for natural gas deliveries. The "joining of forces" should mean an early start on construction of the $163,000,000 project. Pacific Northwest still must complete financing for its line, but the agreement is expected to speed negotiations. Pipe for most of the line is on order.

Regulation of prices on processed natural gas sold for interstate shipment is the business of the Federal Power Commission, not of the states concerned, and such power apparently exists without the benefit of federal laws. That's the gist of the Supreme Court's ruling on the Oklahoma minimum price regulation, thrown out by a brief 7-to-1 opinion in April. The Oklahoma law had set a minimum price of 9.8262 cents per thousand cu ft on processed gas from the Guymon-Hugoton field. The Oklahoma Supreme Court had upheld the law on the basis that it was passed to eliminate waste and for conservation purposes and was therefore within the state's power. The appellant, Natural Gas Pipeline Company of America, contended the action interferred with interstate commerce and that regulation of prices was an FPC matter, not that of the state. The company also contended that the price regulation had the "drastic effect of transferring from the pockets of consumers of gas to those of a few producers millions of dollars annually." In 1952, the Oklahoma Corporation Commission raised minimum prices from 7 cents to 9.8 cents and for the first time included processed gas as well as raw natural gas.

Expenditures of $1.4 billion by the nation's gas industry are expected during 1955, the American Gas Association estimates. This amount is larger than the $1.1 billion spent during 1954 for construction of new facilities and plant expansion. The estimated 1955 expenditure is approximately $250,000,000 higher than estimated a year ago, and marks 1955 as the second largest construction year in dollar magnitude in history for the gas industry. Biggest projects include the Pacific Northwest pipe line at a cost of $160,000,000 and the American-Louisiana pipe line at a cost of $130,000,000.

XUM



To keep in step with your constantly changing business, your communication system should be examined periodically. In that way, your communications never become outdated — always meet your exact needs at the lowest cost. If you have Bell System service, such studies are a continuing activity.

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PRIVATE-LINE TELEPHONE

TELETYPEWRITER

MOBILE TELEPHONE

METERING CHANNELS

BELL TELEPHONE SYSTEM

PIPE LINE DEVELOPMENTS

★ ★ ★

Roundup of Current Planned and Proposed Construction

NAME OF COMPANY	MILES	PIPE SIZE	LOCATION
CRUDE LINES			
Ar-Mex Pipeline Co.	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Big Horn Pipe Line Company	150	8	Ash Creek field to Midwest station of Service Pipe Line, Wyoming
Kaybee Pipe Line Company	46	10	Griffith, Indiana, to New Buffalo, Michigan
Magnolia Pipe Line Company	215	12-14-16	Loops on West Texas to Corsicana system
Michi, Inc.	222	10	Highland, Indiana, to Elsie and Alma, Michigan
NNCW Pipe Line Co.	127	8-10	Weston County to Casper, Wyoming
Orchard Pipe Line	45	8	Orchard to Merino, Colorado
Peace River Oil Pipe Line Co., Ltd.	200	12-16	Peace River area to Edson station on TransMountain near Edmonton, Alta
Powder River Pipe Line Company	436	10-16	Williston Basin to Laurel and Billings, Montana
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.
Roosevelt Oil & Refining Corp.	22	4.6	St. Helen to Norwick, Michigan
Skelly Oil Company	14	6	Lines in Reno and Kingman counties, Kansas
Butte Pipe Line Company	455	16	Williston Basin area of Eastern Montana to Gurley and Ft. Laramie, Wyoming
Sinclair Pipe Line Company	31	12-16	Monee to Lemont, Illinois
West Coast Pipe Line Company	960	20-22	Wink, Texas, to Norwalk, California
PRODUCTS LINES			
American Pipe Line Company	1910	8 to 26	Beaumont, Texas, to Newark, New Jersey, with laterals
Ar-Mex Pipe Line Company	130	8	Tucson to Coolidge to Phoenix, Arizona
H. W. Bass & Sons, Incorporated	152	4-6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas
Bell Oil and Gas Company	140	6-8	Ardmore to Cushing, Oklahoma
Bowen Oil and Management Company (LPG Line)	460	10	Midland to Texas City, Texas
Buckeye Pipe Line Company	200	8	Conversion of existing crude line from connection with Wolverine Pipe Line near Michigan-Ohio border to Cleveland, Ohio
California-Oregon Pipe Line System	103	6	Crescent City, California, to Medford, Oregon
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U. S. Canadian Border
El Paso Natural Gas Co. (LPG Line)	119	3-6	Bloomington to Gallup, New Mexico
Goliad Corporation (LPG Line)	117	4-6	Kittie Plant to Corpus Christi, Texas
Inland Corporation	37.5	10	Toledo to Fostoria, Ohio
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota
Keystone Pipe Line Company	48	8	Boot Station to Fullerton, Pennsylvania
Malco Pipeline, Inc.	91	6	Prewitt to Albuquerque, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana, to Minot, North Dakota
Shamrock Pipe Line Corp.	100	6	Amarillo to Abernathy, Texas
Sioux Oil Company	50	6	Newcastle, Wyoming, to Rapid City, South Dakota
Socony-Vacuum Oil Co. Eastern Pipe Lines	5	12	Linden, New Jersey to Port Socony on Staten Island, N. Y.
Southern Pacific Pipe Lines Company	800	6 to 16	New products lines system in California, Arizona, New Mexico and Texas to be built and operated by Southern Pacific Railroad Co.
Standard Oil of Indiana	47	8	Manhattan to Lemont, Illinois, and Manhattan to Chicago River Terminal
Sunflower Pipe Line Company (LPG Line)	265	3-6	Kearny, Grant and Haskell counties to Wichita, Kansas
Texaco-Cities Service Pipe Line Company	45	8	West Tulsa to Cushing, Oklahoma
Winnipeg & Central Gas Co. (LPG Line)	330	6	Tioga, N. D., to Winnipeg
GAS LINES			
Alberta Gas Trunkline	315	18-36	Gas Gathering System in Alberta fields
American-Louisiana Pipe Line Company	1120	22 & 30	Lowry, Louisiana, to Detroit, Michigan
Anadarko Basin Pipeline Co.	525	24	Wise County, Texas, to Memphis, Tennessee
Arkansas-Louisiana Gas Company	136	8 to 24	Loops on System
Central Hudson Gas and Electric Co.	48	12	TGT line to Kingston, N. Y.
City of Fayette, Alabama	20	5	Fayette, Alabama, to Southern Natural's system
Coast Counties Gas Electric Company	40	3-4-8	Coast and Valley Region, California
Coastal Transmission Corporation (c/o Delhi Oil, Dallas)	400	30	McAllen to Beaumont, Texas
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado
Colorado Interstate Gas Company	110	6-8	Julesburg area to Denver, Colorado
Colorado-Western Pipe Line Co.	328	16-18	Ignacio field to Pueblo and Denver
Colorado-Western Pipe Line Co.	454	—	Cortez to Denver System
Colorado-Western Pipe Line Co.	250	—	Lateral lines
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia
El Paso Natural Gas Co.	370	—	Mountain Home, Idaho, to Reno, Nevada
El Paso Natural Gas Co.	74	—	Additions to Permain Basin-San Juan Basin system
Fort Worth Basin Gas Company	—	—	Brown and Comanche counties, Texas
Kansas Pipe Line Company	125	16-20	Barber County fields to Wichita, Kansas
Kansas-Nebraska Natural Gas Company	206	6-12	Additions to Nebraska system
Manufacturers Gas, Light & Heat	40	—	Allegheny, Washington, and Beaver counties, Pa.
Manufacturers Gas, Light & Heat	213	3 to 26	Various points on system in Pa., W. Va., and Ohio
Manufacturers Gas, Light & Heat	72	16-20	Doddridge, Wetzel and Marshall Counties, West Va.
Michigan Consolidated Gas Company	25		Sparta to Muskegon, Michigan
Michigan-Wisconsin Pipe Line Company	252	4-24	Loops and stations in Illinois
Mississippi River Fuel Corporation	190	10-18	Laterals in Woodlawn and Waskom gas fields, Texas
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky
Natural Gas Pipe Line Co. of America	350	20-26	Amarillo to Wise County, Texas
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado
Natural Gas Producer, Inc.	61	4-10	Northeast Colorado lines
Natural Gas Storage Company	35	36	Storage field areas near Chicago to main lines
New River Gas	50	—	Sumners to Monroe counties, West Virginia
North Dakota Natural Gas Company	475	6-12	Statewide system in North Dakota
Northern Indiana Fuel & Light	35	8	Edgerton to Alburn, Indiana
Northern Natural Gas Company	330	2-12	System in South Dakota
Northern Natural Gas Company	310	24	Lines in North Dakota
Northern Natural Gas Co.	403	24-30	Canadian border to Minneapolis-St. Paul
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton, Alberta, Canada
Pacific Northwest Pipeline Corp.	1486		Ignacio, Colorado to Bellingham, Washington
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off main line to Pocatello, Idaho, to Yakima, Washington
Pine Tree Natural Gas Co.	204	—	Boston to Bangor, Maine
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York
Shenandoah Gas Company	39	3-4-8	Middleton, Virginia, to Martinsburg, West Va.
Tennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut
Tennessee Gas Transmission	370	30	Agua Dulce, Texas, to Kinder, Louisiana
Texas Eastern Transmission Corp.	328	24	Beaumont to Kosciusko, Mississippi
Texas Gas Transmission Co.	90	20-26	Loops on main line
Texas Gas Transmission Co.	100	10-20	New Indiana lateral line
Transcontinental Gas Pipe Line Corporation	125	—	Ulster County, New York (Pheoncia) to New York City
Transcontinental Gas Pipe Line Corporation	315	36	Loops on main system
	219	30	Loops on main system
Transcontinental Gas Pipe Line Corporation	46	12-16	Other new lines
Trans-Canada Pipe Lines, Ltd.	2247	14-34	Alberta area to Toronto, Montreal
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.
Warren Petroleum	54	4-30	Lea County, New Mexico
Westcoast Transmission Co., Ltd.	650	30	Peace River area, Alberta, to U. S.-Canadian border
Wilcox Trend, Gathering System, Inc.	16	6	Loop near Provident City, Texas. Also plans additions to gathering systems.
Wyoming Gas Products Corp.	—	—	Gas gathering system in Weston County, Wyoming

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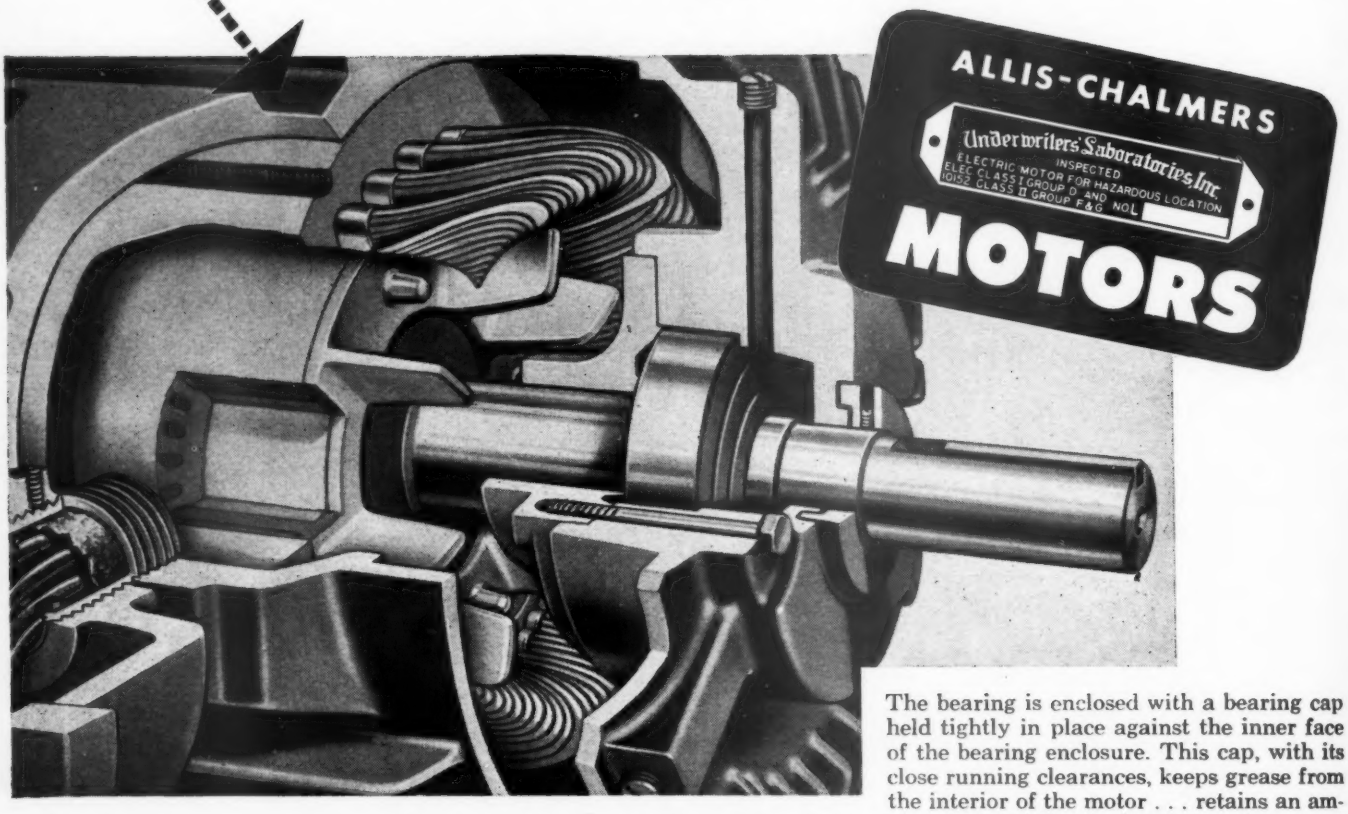
Get Both bearing features



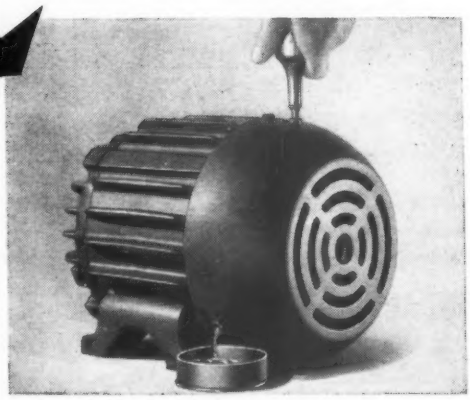
fully enclosed and protected

The bearing is enclosed with a bearing cap held tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, keeps grease from the interior of the motor . . . retains an ample supply within the bearing enclosure.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt traps.

. . . yet easy to grease

You can lubricate the bearings without dismantling the motor. Pipe-tapped holes in the bearing housings at three points provide both means for inserting new grease and a means of flushing out old grease.



Look for the extra bolts on the end housing . . . the sign of greater value. Ask your Allis-Chalmers representative or Authorized Distributor to show you a cutaway section of this maintenance-cutting design. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 51B7286.

A-4610

ALLIS-CHALMERS

MARVEL INVERSE OILER—

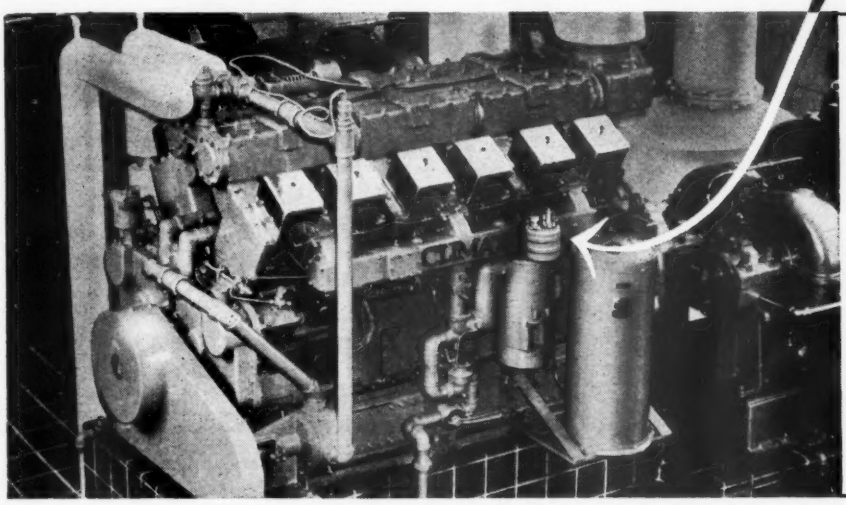
Vital Part of World's Finest Engines

Engine manufacturers think so highly of the Marvel Inverse Oiler they have incorporated it as a vital unit in their engines' lubrication systems.

They have found that engines, equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down-time" low by extending periods between overhauls.

The famous Climax Engines, one of which is pictured below, is an example. A truly fine performer, it is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant of all.

The Marvel Inverse Oiler feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. Keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages. Remember, it is the *oil* which must do these things and only Marvel Mystery Oil is blended for this purpose and for this oiler.



The Marvel Inverse Oiler

is an integral part of the Climax 12 cylinder, 171 H.P., 600 RPM GAS ENGINE. Operating off the intake manifold, this completely automatic Oiler feeds Marvel Mystery Oil exactly in proportion to engine loads . . . gives direct protection to the all-important upper cylinder areas.

This Chart shows the proper setting for constant load engines

BRAKE H. P. AT BELT	NAT. GAS CU. FT. PER HOUR	BUTANE GALLONS PER HOUR	GASOLINE GALLONS PER HOUR	M. M. OIL DROPS PER MIN.	M. M. OIL HOURS PER QUART
10	115.	1.07	1.12	4	228
15	172.5	1.60	1.68	6	152
20	230.	2.14	2.24	8	114
25	287.5	2.67	2.80	10	91
30	345.	3.21	3.36	12	76
35	402.5	3.74	3.92	14	65
40	460.	4.28	4.48	16	57
45	517.5	4.81	5.04	18	50
50	575.	5.35	5.60	20	45
60	690.	6.42	6.72	24	38
70	805.	7.49	7.84	28	32
80	920.	8.56	8.96	32	28
90	1035.	9.63	10.08	36	25
100	1150.	10.70	11.20	40	22
120	1380.	12.84	13.44	48	19
140	1610.	14.98	15.68	56	17
160	1840.	17.12	17.92	64	14
180	2070.	19.26	20.16	72	12
200	2300.	21.40	22.40	80	11
225	2587.5	24.00	25.20	90	10
250	2875.	26.75	28.00	100	9
275	3162.5	29.42	31.10	110	8
300	3450.	32.10	33.60	120	7

Chart shows total oil consumption

EXAMPLE:—If you use 805 cu. ft. of dry gas, 7.49 gallons of butane or 7.84 gallons of gasoline, your H.P. is about 70, so adjust oiler to feed 28 drops per minute. You will then receive about 32 hours per quart of MARVEL MYSTERY OIL.

If engine load increases after setting for normal load, oiler will automatically increase its feed, decreasing when load is lessened.

To determine drop count per oiler when more than one is used on an engine—divide recommended drop count by number of oilers.

NOTE: Guarantee on oiler is void if any other oil than MARVEL MYSTERY OIL is used. Some *engines* also carry this guarantee policy.

See Your Local Jobber or Oil Well Supply House

EMEROL MFG. CO.

Dept. 429, 242 West 69th Street New York 23, N. Y.

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Greater capacity, improved reliabilty highlight . . .

Advances in Multi-Channel Microwave Communications

New concepts in automatic pipe line controls, the use of microwave for centralized office accounting, the economic advantages of high channel capacity, have posed tighter requirements on microwave system reliability; here's a roundup of these improved techniques and equipment

E. P. Elmore, Jr.

THE PETROLEUM INDUSTRY PIONEERED the commercial application of microwave for multi-channel communications. The economic and engineering wisdom of this speculation has been proved by 15,000 miles of microwave systems now serving the petroleum inindustry. Six of the operating microwave systems exceed 1000 miles in length and provide pipe line communications of higher reliablility and lower cost than possible with wire lines or leased circuits.

The early microwave systems provided ample reliability and moderate capacity for pipe line communication functions including telephone, VHF tie-in, telemetering, teletype and supervisory control. New concepts in pipe line automatic control and in the use of microwave for centralized office accounting, however, are imposing more stringent requirements upon the reliability and continuity of microwave communication systems.

The cost-per-channel over a microwave system is progressively lowered by the addition of channels. This economic factor favors high density channelizing, thereby encouraging multipurpose usage of a microwave system or even joint ownership when trunkline routes are compatible. Heavy traffic over a communication system necessitates higher reliability but also provides economic justification for more careful attention to equipment and engineering for continuous performance.

Microwave systems available today can be supplied to meet almost any desired degree of reliability, channel capacity, and performance. Significant advances in microwave reliability have been made as a result of (1) lessons in the school of hard knocks—field operation, (2) the value of hindsight in equipment design, and (3) new components and techniques, best exemplified by the application of mechanical filters to single sideband multiplexing.

EXCLUSIVE

Mechanically-Filtered Single-Sideband Channels

THE DEVELOPMENT OF THE MECHANICAL passband filter has been a major contribution to the art of multichannel communications, both in reliability and in the technique of single sideband selection. These rugged, permanently-tuned mechanical devices provide a highly selective channel filter with a passband approaching the ideal rectangular shape. This innovation provides a simple, reliable, compact and economical means of obtaining single sideband suppressed carrier, or SSB-SC channels.

The use of SSB-SC channels for microwave communications is highly desirable because it affords the most efficient and practical means of transmitting a moderate or large number of high quality channels. The major advantages of SSB-SC over other types of multiplexing are (1) efficient loading of the RF system and (2) economy of bandwidth.

Since SSB-SC channels utilize only one sideband and suppress the carrier, full power can be allocated the single sideband. This single sideband transmits only useful intelligence; the subcarrier does not contribute to the signal intelligence, and double sidebands merely increase the bandwith and thermal noise power. Statistical studies have shown that the signal energy in a number of SSB-SC channels does not peak simultaneously but combines in a random manner. The strong statistical advantage of SSB-SC permits allocation of a large portion of the total RF deviation to each channel. RETMA recommendations for a 24 or 32 channel system, for example, are for assign-

ment of 1/6 the total FM deviation of the RF output to each channel.

The presence of continuous carriers (as in FM subcarrier systems or double sideband AM systems) imposes a burden on the RF loading. Continuous carriers also pose intermodulation problems as a result of harmonics and sum-and-difference frequencies of these carriers occurring within channels. A partial solution to these carrier problems with FM-FM or DSB-AM multiplexing has been to provide party-line channels to mask intelligible tones. Pulse systems theoretically offer a very high information capacity, comparable to SSB-SC, but the extremely wide bandwidths, complex circuitry, and difficulty of drops have been serious problems in providing and maintaining reliable circuits.

Single sideband generation is a simple process. A voice frequency signal is mixed with a convenient carrier to produce double sideband products, then a bandpass filter is employed to select one of the sidebands. The filter may be an LC filter, crystal filter or mechanical filter. LC filters are practical at low frequencies and provide reasonable selectivity. Crystal filters provide very sharp selectivity but are cumbersome and expensive. Mechanical filters permit sharp selectivity at frequencies from 60 kc to 800 kc. For economy of types, however, it is preferable to generate the single sideband channels at a convenient frequency such as 250 kc, then position the channels to the desired portion of the baseband spectrum by a heterodyne process.

The bandpass characteristic of a mechanical filter can be readily understood by reference to Fig. 2, the mechanical filter functional diagram. A low-level electrical signal is converted into mechanical vibration by action of the transducer coil on a magneto-structive driving rod. A bias magnet, similar in function to the magnet in the ear-piece telephone, is used to prevent double frequency vibration. The mechanical vibrations are coupled through a number of resonant disks, each precision tuned to mechanical resonance at a specific frequency in the vicinity of 250 kc. The high frequency mechanical vibrations are converted back to an electrical signal by the reverse process at the far end.

The overall passband achieved by this series of resonant disks is almost rectangular. The bandwidth may be 100 cps to 6000 cps. Filters employed in present multiplex equipment have a bandwidth of 3000 cps. The top of the passband is flat within 3 db and the "skirts" are sharper than in an IF amplifier employing 10 cascade tuned circuits. This sharp selectivity is provided in a rugged, fixed-tuned sealed unit approximately 3 by 1 by 1-in.

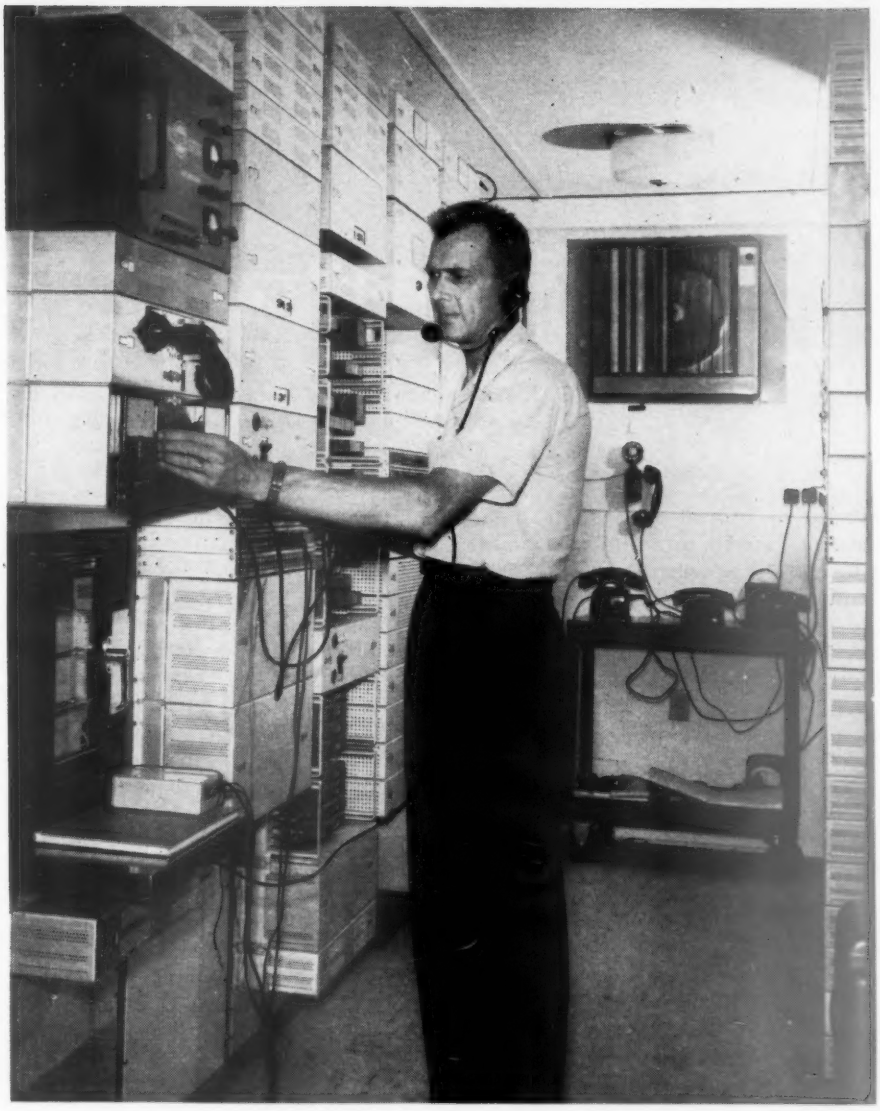
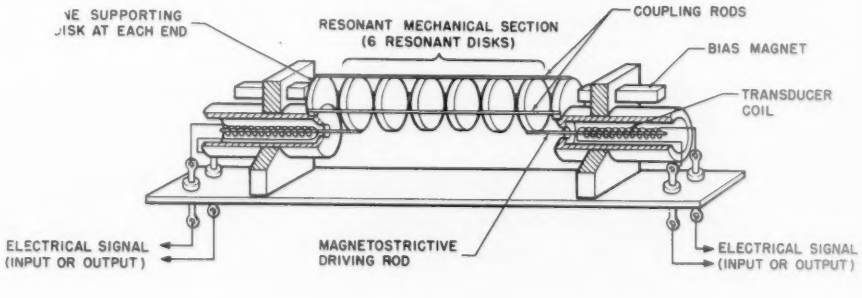


FIG. 1. Interior of a 32-channel microwave terminal. High degree of equipment reliability obtained by incorporation of mechnical filters, magnetic amplifiers, low-power Klystrons, ARINC tubes, non-critical IF amplifiers, and improved standby power control appartus.

A mechanically-filtered modulator and demodulator, or "modem," which provides one SSB-SC multiplex channel is shown in Fig. 3. The corresponding block diagram of a mechanically-filtered modem is shown in Fig. 4 illustrates the technique of single sideband channelizing. In the modulator the voice frequency signal is mixed with a 250 kc carrier.

The output of the balanced modulator is the upper and lower sideband of 250 kc, with the carrier partially sup-

FIG. 2. Diagram shows mechanically resonant discs, stagger-tuned to provide almost ideal rectangular passband for single sideband selection.



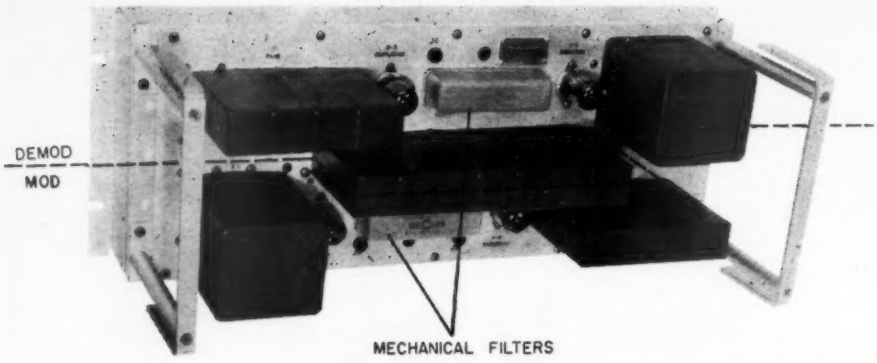


FIG. 3. Modem shows rugged, fixed-tuned mechanical filters employed to select upper or lower sideband.

pressed by cancellation action in the balanced modulator. The mechanical filter shown then selects the lower sideband of 250 kc and further suppresses the carrier. The result is the single sideband intelligence that is then positioned to the desired subcarrier frequency allocation by heterodyne action with a channeling frequency (f_{sc} + 250 kc).

The demodulator action is the reverse process. The channel frequency is passed by an LC filter and mixed with the channeling frequency to convert to the 250 kc region. The mechanical filter then selects the proper sideband and this intelligence is converted to audio by heterodyning with 250 kc. The linearity of this overall process is indicated by a distortion specification of less than 1 per cent for the back-to-back multiplex at 0 dbm levels.

The output of each modulator consists of the upper (or lower) sideband associated with a suppressed subcarrier. The selectivity of the mechanical filter pair is sufficiently sharp to permit the upper and lower sideband to be utilized for separate channels. Fig. 5 shows the output of two modulators, illustrating the transmission of two channels per subcarrier.

This technique of twin channel or *bilateral* SSB-SC reduces the amount of frequency generating circuits and permits closely spaced channel pairs. The quality of these bilateral SSB-SC channels is quite high; the adjacent channel crosstalk is more than 55 db down, and the overall noise-plus-crosstalk on a typical 24-channel system is better than 23 dba as measured using F 1A weighing.

Microwave System Reliability

THE RELIABILITY OF EARLY SYSTEMS is indicated by published figures on the per cent outage per station. This outage time per station ranged from 0.02 per cent to 3.8 per cent. A typical figure after 2 years of operation is 0.12 per cent outage time per station due to all causes. The overall reliability of a 1000-mile system involving approximately 40 stations in series was therefore in the order of 95 per cent.

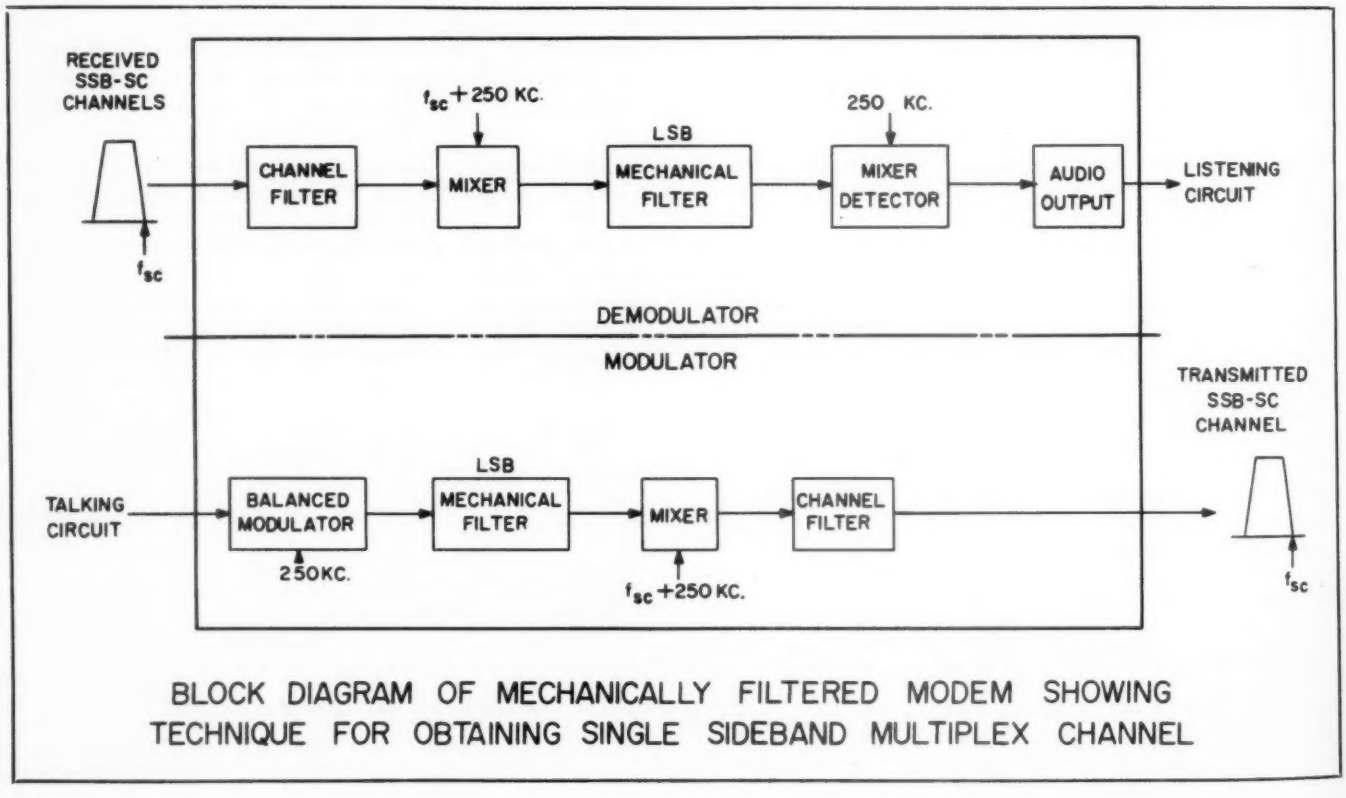
The bulk of this outage time was due to loss of a-c power to the equipment resulting from malfunction of the power transfer process, standby generator not starting or running out of fuel, etc.

A minor portion of this outage time was due to microwave equipment failure. This outage due to electronic equipment failure was reduced by a factor of two in systems employing standby RF equipment to minimize outage during travel time to the site.

An almost negligible amount of the outage time was due to propagation fades. Fades down to noise level occurred but were generally of short duration except on problem paths. The length of these deep fades due to multipath transmission was less at the shorter wavelengths, so that most fades in the 7000 mc band resulted in loss of only a few syllables.

Microwave systems are reliable and easy to maintain chiefly because they 'lump' all communication facilities at fixed sites approximately 30 miles apart, thus eliminating outage due to

FIG. 4.



BLOCK DIAGRAM OF MECHANICALLY FILTERED MODEM SHOWING TECHNIQUE FOR OBTAINING SINGLE SIDEBAND MULTIPLEX CHANNEL

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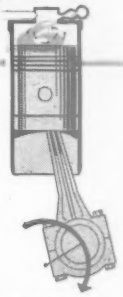

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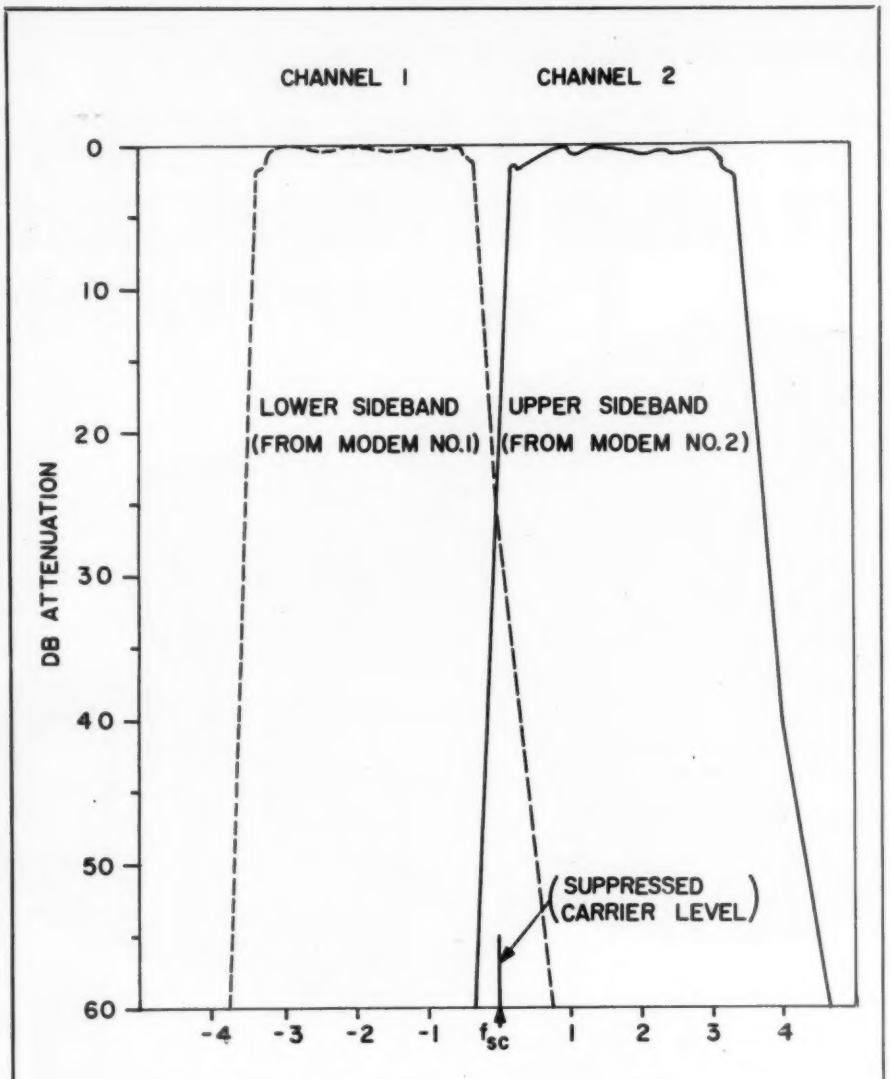
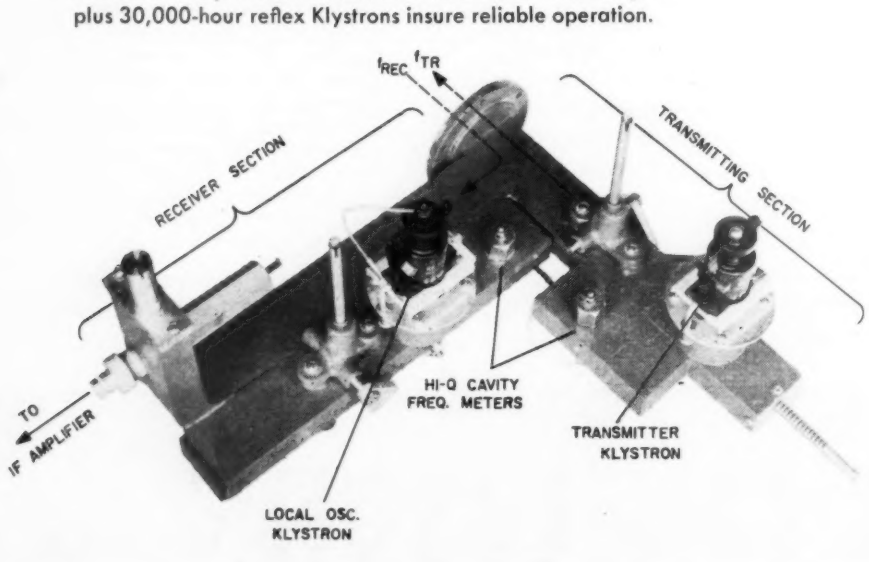


FIG. 5.

FIG. 6. Microwave "Plumbing." Heart of a 7000 mc transmitter-receiver. Temperature stabilized mechanical "circuitry" plus 30,000-hour reflex Klystrons insure reliable operation.



intermediate faults or storm conditions that may disrupt or attenuate wire line communications. The problems of microwave system reliablility are therefore localized and reduced to (1) maintaining a-c power at the station sites, (2) minimizing the electronic equipment outage time, and (3) providing and maintaining sufficient fade margin.

The degree of a-c power reliability is today simply a matter of dollars. Major improvements have been in automatic power transfer apparatus and standby power generating systems. Automatic line transfer controls now incorporate the recommendations of microwave manufacturers and users, including provision for automatic or remotely controlled exercising.

Improved gasoline engine generators, LPG units, and propane power plants provide sure-starting for reliable standby power where a short outage time can be tolerated. When continuous operation is necessary to avoid loss of control pulses or other essential data, flywheel type generators or continuous power systems employing converters with battery banks are available.

The major cause of electronic equipment outage has been vacuum tubes. The design goal therefore, has been to eliminate tubes wherever possible and to employ reliable types, low power levels and under-rated operation where tubes are an absolute must. Tubes have been eliminated in many cases by substituting magnetic amplifiers, by using mechanical filters or by improved design. In this the microwave design engineers have been quite successful. Microwave equipment incorporating magnetic amplifiers and ARINC-approved tube types has demonstrated such high reliablity that these design principles are now being applied to airborne radar equipment.

The most reliable transmitting tube ever applied to communication purposes is the *reflex* klystron. Klystrons were used during World War II as local oscillators in radar receivers. The reflex klystron is a low power source of microwave energy that may be frequently deviated by the application of a low-level AM signal on the repeller. Although the RF power output is relatively low, large power gains can be realized by the use of parabolic antennas that focus the microwave energy into highly directive beams.

Klystron output powers of less than one watt may be used in conjunction with high gain antennas in the 4000 to 7000 mc region to achieve reliable propagation links. Equipment gains in the order of 110 db (difference between transmitter output and receiver sensitivity) plus two times the gain of the dish are available for overcoming

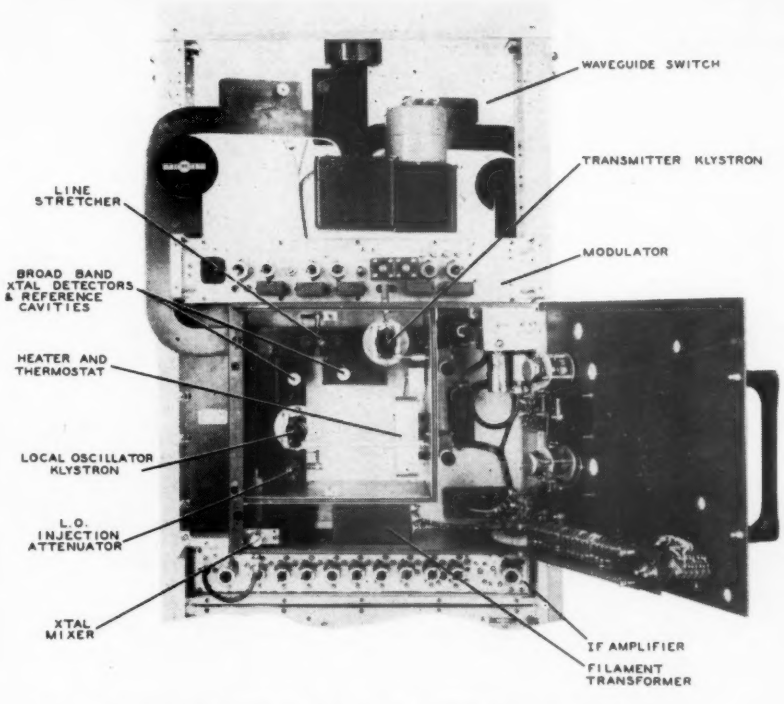


FIG. 7. Transmitting and receiving equipment, showing AGC modulator, 6700 mc RF box and fixed-tuned IF amplifier. Fault sensing causes waveguide automatically to switch over to standby RF on rear of rack in event of main RF failure.

space loss and providing fade margins.

Klystrons have evolved to the point where a tube life of 30,000 to 50,000 hours is normally expected with tubes such as the Raytheon 5976. As these tubes are low-power devices, they do not fail in the fashion of high-powered transmitting tubes. Instead, they generally decline in RF output and beam current in such a manner that a monthly reading of tube current suffices to detect deteriorating tubes before failure occurs.

The klystrons and their associated plumbing constitute the heart of a microwave system. Fig. 6 shows such a plumbing arrangement. The reliability of these long-life klystrons and temperature-stablilized electro-mechanical plumbing is obvious. The transmitter as shown is complete except for a video amplifier incorporating AGC. The preselector, local oscillator, and mixer portions of the receiver are shown; only the IF amplifier is needed to complete the receiver.

IF amplifiers have been notorious as causes of microwave equipment failure. Half the tubes used in a microwave RF terminal rack are in the IF amplifier, which is naturally critical as a result of its high gain, high frequency, and wide bandwidth. Screwdriver adjustments have been a greater threat to performance than tube failure.

Solutions have been found to minimize the problems of IF tube failure and misalignment. Fixed-tuned IF strips have eliminated all inter-stage adjustments, thus minimizing field alignment problems and dangers. A low IF frequency of 60 MC is being used and extra tubes are incorporated to permit heavily derated operation of stages and components. These precautions, plus painstaking design, have resulted in an IF amplifier which is noncritical and highly reliable.

The application of magnetic amplifiers to microwave equipment has permitted the realization of a tubeless regulated power supply. Klystron d-c voltages must be well-regulated for frequency stability, and the series regulation tubes normally employed for this purpose are hard-driven and subject to frequent failure. Fig. 8 shows a 130-v d-c supply employing 4 series regulative tubes, and Fig. 9 shows the new 130-v tubeless supply that employs magnetic amplifiers to achieve comparable regulation.

Two magnetic amplifiers of the saturable reactor type are employed in feedback loops from the secondary to the primary side of the power transformer. The control winding of one magnetic amplifier bridges a small resistor in series with the B-plus lead and serves as a current feedback loop to compensate for variations in load current. The other magnetic amplifier serves as a voltage feedback loop to compensate for variations in d-c voltage level due to changes of line voltage or component aging. The use of magnetic amplifiers has eliminated 14 series regulation tubes per RF terminal rack.

The d-c output voltage of the 130 v magnetic-amplifier-regulated supply will vary less than 2 per cent with a-c voltage fluctuations between 90 and 135 v and variation of load current from 50 to 350 ma.

Tubes for Microwave System

The quantity and types of tubes required for a microwave station have been considerably reduced by the use of magnetic amplifiers, mechanical filters, and careful tube selection. The tube complement of a microwave terminal employing long-life klystrons and ARINC-approved tube types is shown in Fig. 10. The RF tube complement is for non-switchover equipment; the addition to standby would approximately double the complement but not alter the operating quantity appreciably. The multiplex terminal complement is tabulated on a per-channel basis for 24 duplex 4-wire channels.

The Author

E. P. "Lee" Elmore, Jr., is an electrical engineer with nine years of experience in the field of communications and electronics. He joined the headquarters sales staff of Collins Radio Company in Dallas, Texas, as a microwave sales engineer in March, 1954, and is now in charge of the microwave department of the communication sales division. His responsibilities include planning and proposing of microwave systems and other technical and staff sales duties associated with the microwave and multiplex product lines.

Prior to obtaining his BSEE degree from Duke University, he worked as a broadcast transmitter operator and instal'ed several radio stations in North Carolina and Florida. For three years he was a senior engineer with the research division of the Philco Corporation in a staff capacity associated with development of TV receivers, NTSC color, microwave, transistors and radar systems. Before joining Collins he was with the Magnavox Company, where he was engaged in administrative engineering work that included scheduling and budgeting of engineering projects. He is a member of the IRE, AIEE, PESA, and microwave section of the RETMA technical products division.

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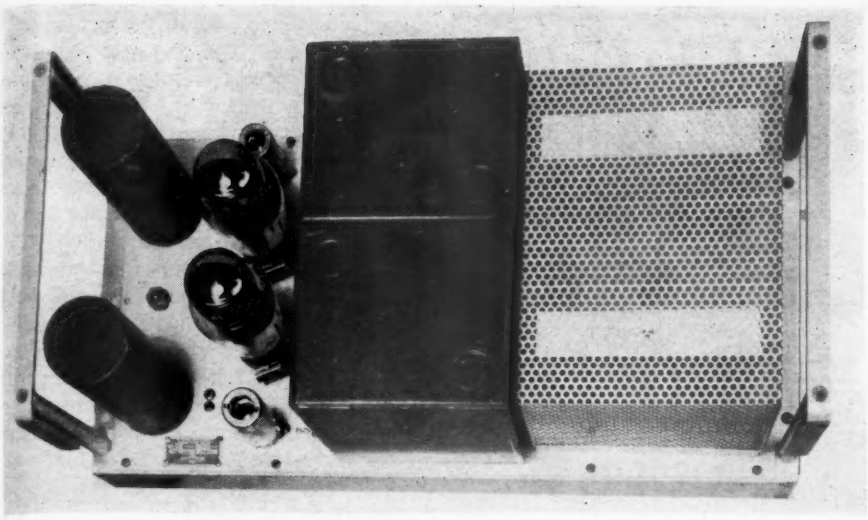

FIG. 8. Unit above is 130-v d-c supply employing four series regulation tubes.

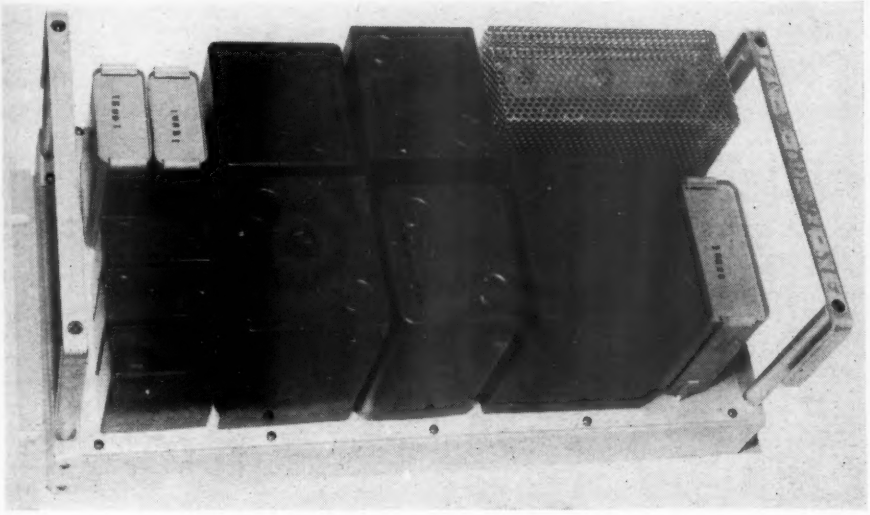

FIG. 9. Similar power unit is new 130-v tubeless supply that uses magnetic amplifiers for regulation; vacuum tubes are eliminated by mag-amps and industrial rectifiers.

The addition of 4/2 wire termination panels with signaling and ringing provisions would add 1 to 3 tubes per channel, depending upon the type of terminating facilities.

Careful selection of receiving tube types and conservative design in the application of tubes have resulted in highly reliable vacuum tube operation. Receiving tube types employed in consumer products do not provide the tube life or quality needed for commercial communications; these receiver tubes are guaranteed for 90 days (2160 hr) but may fail within weeks or may survive for 18 months. There are several categories of reliable tube types that exhibit a much longer and predictable tube life. These reliable tube types include industrial long life tubes, ruggedized tubes, and the ARINC-approved reliable tubes that were developed for commercial airline usage. These reliable types are all manufactured to high quality standards and close tolerances. At least 10,000 hr of useful life are expected, and continuous operation for two or three years without failure is commonplace with reliable tube types.

Propagation and Performance Reliability

These improvements in equipment reliability are focusing greater attention on the propagation links and overall system performance. Planning a microwave system for reliable point-to-point communications of a specified quality requires that the propagation path, as well as the microwave and multiplex equipment, be considered an integral part of the system. The equipment factors are controllable, but the propagation link is subject to the variables of nature. These variables are reasonably predictable for line-of-sight paths. Sufficient operational data have been obtained from microwave systems and propagation experiments during the past few years to permit planning of microwave links to allow for, avoid, or even take advantage of microwave propagation phenomena.

FIG. 10. Reliable tube complement.

Equipment	5976 Reflex Klystron	ARINC—approved types 5670	5654	5749
Terminal RF	2	3	12	1
Relay RF	4	6	24	2
Multiplex terminal (per channel, with 24 duplex 4-wire channels)	—	5½	1¼	—

An example of avoiding propagation difficulties is the practice of avoiding over-water shots unless diversity reception is employed to compensate for fades due to strong multipath transmission and resultant signal cancellation. Other problem paths requiring special consideration include shots through sharp inversion layers that may cause pronounced bending or severe ducting. A field survey permits selection of sites, propagation paths, and tower heights so as to avoid these severe fading problems.

The usual procedure in microwave path planning is to make allowance for the expected variables by provision of ample fade margins. The provision of first Fresnel zone clearance throughout a path provides essentially free space transmission under no-fade conditions. Fade margins may then be incorporated into the system to provide propagation links of the required reliability.

The overall performance of a microwave link may be shown graphically as in Fig. 11, which is calculated for a 6700 mc link with 110 db transmitter-receiver gain and employing SSB-SC channels. This chart may be used to plan or specify point-to-point multichannel communication circuits of any practical quality and reliability. The voice channel quality is indicated by the db and dba scale showing audio signal-to-noise ratio. A yardstick for gaging relative quality parallels the dba scale.

Communication reliability is provided by the fade margin indicated on the RF carrier-to-noise scale. The performance of a system under varying propagation conditions can be predicted from the chart as shown in the example. The path length scale can be used to determine the operating conditions during free space or "normal" propagation. In the example of a 40-mile path using 6 ft dishes, the "normal" RF carrier-to-noise ratio is ap-

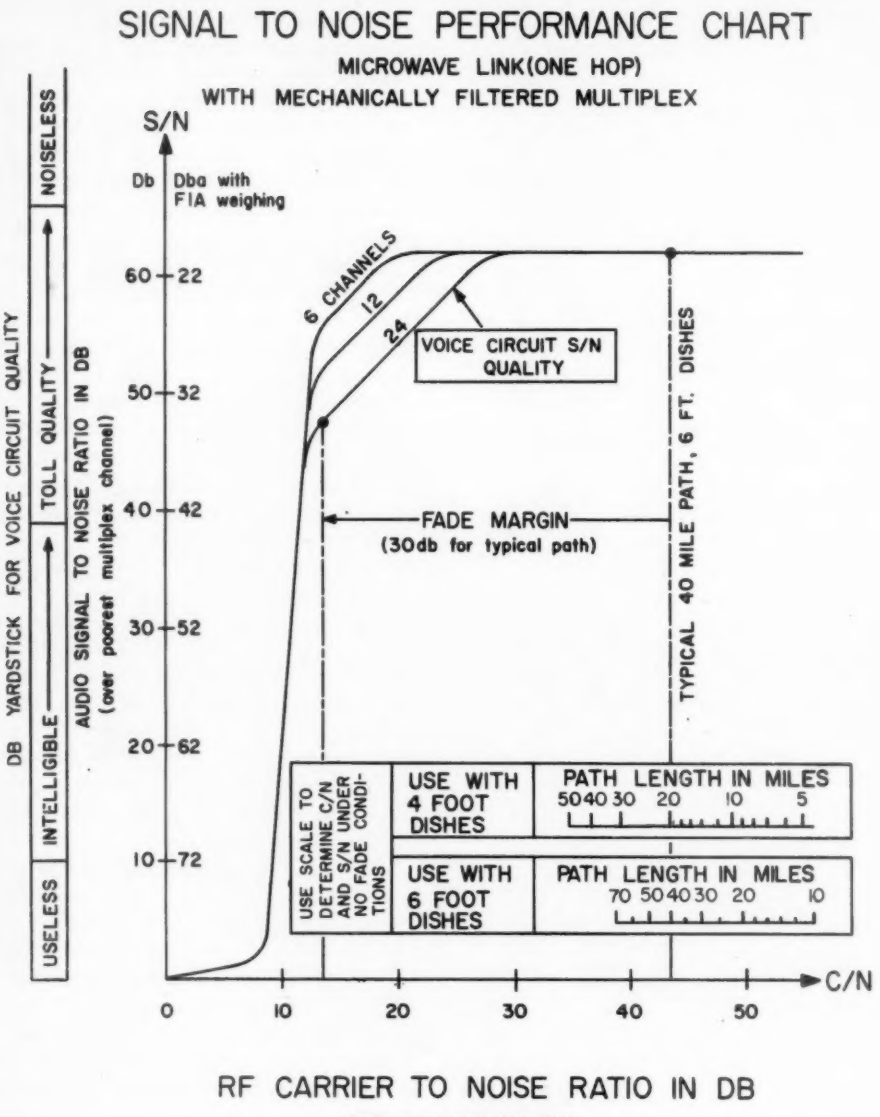

FIG. 11.

proximately 43 db and the corresponding voice circuit signal-to-noise quality is better than 60 db. Over well-planned paths, this high quality will be the median or normal signal.

As a fade occurs, the RF carrier-to-noise ratio will be decreased by an equal number of db, causing operation further to be left on the curve. In the example of a 24-channel link, the voice quality is unaffected by moderate fades. A 3-db decrease in the circuit quality will not occur unless the fade is approximately 20 db in depth. Fades of this magnitude occur less than 1 per cent of the time over most paths. As the fade deepens, the voice quality will decrease proportionately down to the FM threshold, beyond which the quality drops rapidly. Incorporation of a 30-db fade margin in the sample system would provide a minimum voice circuit quality of 50 db or better in excess of 99.9 per cent of the time over most paths.

The system engineering of a microwave communication system has a strong bearing on the overall reliability. System engineering is essentially a problem of matching the equipment and propagation path to provide the desired communication and control functions. The varied equipment—microwave, multiplex, antennas, towers, buildings, standby power, existing facilities—must be physically and electrically compatible if major field modifications or installation difficulties are to be avoided. Headaches are minimized by one company responsible for the overall system, and the engineering department of the communication equipment manufacturer is naturally best qualified to engineer the system and guarantee overall performance.

In routing microwave systems through rugged terrain, it is sometimes difficult to locate practical sites that provide line-of-sight paths. Selection of sites far removed from existing access roads or primary power lines, costs heavily in dollar requirements and in reliability of such remote stations. The use of passive reflectors ("billboards") or passive relays (back-to-back dishes) may sometimes be used to overcome obstacles. Both techniques are an extension of the reflecting and gathering techniques employed in antenna systems at the higher microwave frequencies. Billboards are useful for bouncing the microwave beam off nearby mountains to a far terminal. Back-to-back dishes are useful when the obstacle occurs near mid-path. Both techniques are limited to relatively short paths at present because of the losses involved. The incorporation of recently announced high power klystron amplifiers into commercial microwave equipment will greatly extend the use of such signal bouncing and bending techniques.

Maintenance

A well-planned maintenance program is the key to reliable system performance. Poor maintenance not only increases the chance of equipment outage but also reduces the RF transmitter-receiver equipment gain, thereby decreasing the fade margin built into the system.

The best maintenance is preventive maintenance. Preventive maintenance is facilitated by built-in test equipment, a simple but thorough monthly check routine, and well-informed maintenance technicians.

The degree of overall equipment reliability obtainable with present equipment and a good maintenance program is indicated by the operating record of the Collins test link. This two-terminal system was operated for 14 months to thoroughly evaluate the use of mechanical filters, magnetic amplifier, low-power klystrons, ARINC tubes, fixed-tuned IF amplifiers, and improved power transfer control equipment. The system provides 32 channels over a 6700 MC RF link. Twenty-four of the channels are mechanically filtered SSB-SC multiplex in the 300 kc-600 kc octave, and eight additional channels are provided in the low frequency portion of the baseband using SSB-SC telephone carrier equipment. This system employing approximately 500 tubes operated for over one year with no klystron replacements, only three ARINC tube failures, and no fault sufficient to cause automatic switchover to standby RF equipment. * * *

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for pipe line contractors

New Depreciation Methods For Equipment Investments

Better profit and re-investment can be realized under the provisions of 1954 Internal Revenue Code

Perry Schwartz*

BECAUSE OF THE CONTINUING IMPROVEMENTS BEING MADE in pipe line construction equipment, it is vitally important to the pipe line contractor that he be able to appropriately depreciate equipment according to its use and life, and reinvest that capital return in improved equipment.

The liberalized methods of depreciation allowances, as contained in Section 167 of the Internal Revenue Code of 1954, are of special importance to companies whose business is, or is allied with, pipe line construction work.

Returns through depreciation of a larger amount of invested capital in new equipment during the earlier years of its useful life permit a company in the pipe line construction business to reinvest that capital at a more appropriate time in advanced design and improved equipment, and thereby own and have available for use the most modern labor saving machines on the market.

A careful review of Section 167 of the 1954 Code is important in determining what method will provide the means for the most economical operation and result in better profits.

For new equipment acquired and put to work after December 31, 1953, and with a useful life of three years or more, the following methods of depreciation are allowed, without prior approval, under the 1954 Code.

Straight Line Method

This method has been the most commonly used method in the past. It provides that the cost of the equipment, less its salvage value, be depreciated in equal amounts over the estimated useful life of the equipment.

Example 1. Straight line method.

Cost	$6000
Salvage value	—
Depreciable amount	$6000
Estimated useful life	5 years

NOTE: Salvage value is not known; however, it must be recognized and accounted for when equipment is retired.

Year	Depreciable amount	Percentage depreciation	Amount of depreciation	Accrued depreciation
1st	$6000	20	$1200	$1200
2nd	6000	20	1200	2400
3rd	6000	20	1200	3600
4th	6000	20	1200	4800
5th	6000	20	1200	6000

$$\text{Percentage of depreciation} = \frac{100\%}{\text{Years of Useful Life}}$$

$$\text{In this case — percentage of depreciation} = \frac{100\%}{5} = 20\%$$

Amount of depreciation = Depreciable amount × percentage depreciation.

Declining Balance Method

This method provides that a uniform percentage of depreciation be applied each year to the unrecovered cost of the equipment, without regard to its salvage value. Since the unrecovered cost is reduced by prior years' depreciation, the percentage of depreciation is applied to a constantly declining balance.

The percentage of depreciation used under this method shall not exceed twice the normal straight line percentage of depreciation.

Since the declining balance method does not recover the cost until the equipment is sold or scrapped, the 1954 Code permits a change, without the consent of the Commissioner, from the declining balance method of depreciation to the straight line method at any time during the useful life of the equipment.

When the change is made from the declining balance to the straight line method, the unrecovered cost of the equipment at that time must be reduced by its salvage value and the remaining amount depreciated as set forth under the straight line method.

Example 2. Declining balance method

Cost	$6000
Estimated useful life	5 years

Year	Unrecovered cost	Percentage depreciation	Amount of depreciation	Accrued depreciation
1st	$6000.00	(A) 40	(B) $2400.00	$2400.00
2nd	3600.00	40	1440.00	3840.00
3rd	2160.00	40	864.00	4704.00
4th	1296.00	40	518.40	5222.40
5th	777.60	40	311.04	5533.44
Balance	466.56			

(A) Percentage depreciation — allowed to take up to twice per year of the straight line method. Since the straight line method is 20 per cent (example 1), percentage depreciation is taken at the maximum amount of 40 per cent.

(B) Amount of depreciation = Uncovered cost × percentage depreciation.

Unrecovered cost or declining balance is determined by subtracting the depreciation of the prior year from the unrecovered cost of declining balance of that year.

Second year: $6000 — $2400 = $3600, etc.

At the end of the fifth year there is still an unrecovered cost of $466.56. A declining balance reduced by its multiplication of a constant percentage will never result in a zero balance. It is not permitted to charge off as depreciation the total of $311.04 and $466.56 in the fifth year.

*Assistant treasurer, The Jaeger Machine Company, Columbus, Ohio.

EXCLUSIVE

XUM

In order to get a zero balance, a change to the straight line method should be made at the most favorable year of the remaining years of useful life. When this change is made, consideration at the time must be given to the salvage value; however, in this case salvage value will be recognized and accounted for when the equipment is retired.

When to change —

Test — for third year

Cost	$6000
Accrued depreciation, end of 2nd year	3840
Balance	$2160
Remaining useful life	3 years
Depreciation per year	$ 720

Since $720 is less than the $864 depreciation amount for the third year (example 2), no change should be made for the third year.

Test — for fourth year

Cost	$6000
Accrued depreciation, end of 2nd year	4704
Balance	$1296
Remaining useful life	2 years
Depreciation per year	$ 648

Since $648 is greater than the $518.40 depreciation amount for the fourth year (example 2), a change to the straight line method should be made in the fourth year for the remaining two years of useful life.

Example 2A — Combination of declining balance and straight line methods.

Year	Unrecovered cost	Percentage depreciation	Amount of depreciation	Accrued depreciation
1st	$6000	40	$2400	$2400
2nd	3600	40	1440	3840
3rd	2160	40	864	4704
Last two years change to straight line method				
4th	1296(A)		648	5352
5th	648		648	6000

(A) Salvage value will be accounted for when equipment is retired.

Sum of the Years — Digits Method

This method provides that annual amounts of depreciation are computed by applying changing fractions to the cost of the equipment, less its salvage value. The fractions are determined as follows:

A. The numerator is the number corresponding to the remaining years of the estimated useful life of the item of equipment.

B. The denominator is the sum of the numbers corresponding to the years of estimated useful life of the item of equipment.

C. Example: Five years estimated useful life.

Denominator $= 5 + 4 + 3 + 2 + 1 = 15$

Or use formula:

$$S = N \frac{(N+1)}{2} = 5 \frac{(5+1)}{2} = 15$$

Where

N = number of years of useful life

S = sum of the years — digits

then for —

Years of useful life	Depreciation factor
5	5/15
4	4/15
3	3/15
2	2/15
1	1/15

Example 3. Sum of the years — digits method

Cost	$6000
Salvage value	—
Depreciable amount	$6000
Estimated useful life	5 years

NOTE: Salvage value is not known; however, it must be recognized and accounted for when equipment is retired.

Year	Depreciable amount	Fractional depreciation	Amount of depreciation	Accrued depreciation
1st	$6000	5/15	(A) $2000	$2000
2nd	6000	4/15	1600	3600
3rd	6000	3/15	1200	4800
4th	6000	2/15	800	5600
5th	6000	1/15	400	6000

(A) Amount of depreciation = depreciable amount × fractional depreciation.

Other Methods

Any other *consistent method* which during the first two-thirds of the useful life of the item of equipment does not result in an accrued depreciation at the end of any year greater than the accrued depreciation which would have resulted from the use of the declining balance method.

Example 4. Other methods.

Cost	$6000
Salvage value	—
Depreciable amount	$6000
Estimated useful life	5 years

Note on salvage is the same as in Examples 1 and 3.

Year	Depreciable amount	Percentage depreciation	Amount of depreciation	Accrued depreciation	(A) Example 2 accrued depreciation
1st	$6000	25	$1500	$1500	$2400.00
2nd	6000	25	1500	3000	3840.00
3rd	6000	20	1200	4200	4704.00
4th	6000	20	1200	5400	5222.40
5th	6000	10	600	6000	

(A) Declining balance method (example 2) for 4 years; for two-thirds life or 3⅓ years, accrued depreciation is $4876.80. Under other method, accrued depreciation at 3⅓ years is $4600.00.

This is only one example under Other Methods that could be used consistently to comply with the 1954 Code.

Comparison of Examples

(Using 1, 2, 2A and 3 on depreciable amount of $6000)

Year	Percentage of useful life depreciated	Percentage of accrued depreciation Example 1	Example 2	Example 2A	Example 3
1st	20	20	40.00	40.00	33.33
2nd	40	40	64.00	64.00	60.00
3rd	60	60	78.40	78.40	80.00
4th	80	80	87.04	89.20	93.33
5th	100	100	92.22	100.00	100.00

For this item of equipment with an original depreciable amount of $6000 and an estimated useful life of 5 years, under Examples 2, 2A, and 3 the accrued depreciation at the end of 2 years is 60 per cent or more, and at the end of 3 years it is 78 per cent or more, depending upon which method is used for depreciation allowances.

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Limitation of Methods

Example 1 — Machines acquired at any time.

Example 2, 2A, 3 and 4

A. Machines must be acquired after 1953

B. Original use must be after 1953

C. Machines must have a useful life of 3 years or more.

D. Does not apply to used or reconditioned machines acquired after 1953.

E. Does not apply to machines on rental prior to December 31, 1953, and acquired after 1953.

F. Does apply to new machines built prior to December 31, 1953, but not used until acquired after 1953.

Useful Life and Rates of Depreciation

For any property that is subject to the allowance for depreciation, a taxpayer may enter into an agreement with respect to estimated useful life, method and rate of depreciation for taxable years ending after 1953.

Buying New Machines

Re-investment of Capital Investment Plan. Example of how the re-investment of an original capital investment in new machines used for construction purposes will result in owning modern and improved equipment by the application of a liberalized method of depreciation.

Cost of machine $6000
Estimated useful life . . . . . 5 years
Capital investment $6000
New machine acquired on January 1, 1954 and put to work in 1954.
Depreciation method — Example 3
(Sum of the years — Digits method)

Machine No. 1

1-1-54	Investment — $6000 (fully paid)		
1954 --	Depreciation		$2000
1955 --	Depreciation		1600
1956 --	Depreciation		1200
1957 --	Depreciation		800
1958 --	Depreciation		400
	Total depreciation		$6000

Machine No. 2

1-1-55	Investment — $6000		
	Apply as down payment —		
	1954 depreciation Machine No. 1 .		$2000
	Bank loan	$4000	
1955 --	Depreciation	$2000	
12-31-55	Pay on bank loan —		
	Apply 1955 depreciation Machine No. 1		$1600
	Apply 1955 depreciation Machine No. 2		2000
	Total		$3600
	Balance of bank loan . .	$ 400	
1956 --	Depreciation	$1600	
12-31-56	Pay bank loan —		
	Apply 1956 depreciation Machine No. 1		$1200
	Apply 1956 depreciation Machine No. 2		1600
	Total		$2800
	Bank loan		400
	Balance available for re-investment .		$2400
1957 --	Depreciation		$1200
1958 --	Depreciation		800
1959 --	Depreciation		400
	Total depreciation . .		$6000

Machine No. 3

1-1-57	Investment — $6000		
	Apply as down payment —		
	Above balance available for re-investment		$2400
	Bank loan	$3600	
1957 --	Depreciation	$2000	
12-31-57	Pay bank loan —		
	Apply 1957 depreciation Machine No. 1		$ 800
	Apply 1957 depreciation Machine No. 2		1200
	Apply 1957 depreciation Machine No. 3		2000
	Total		$4000
	Bank loan		3600
	Balance available for re-investment .		$ 400
1958 --	Depreciation		$1600
1959 --	Depreciation		1200
1960 --	Depreciation		800
1961 --	Depreciation		400
	Total depreciation . .		$6000
1-1-59	Investment — $6000		
	Apply as down payment —		
	Above balance available for re-investment		$ 400
	1958 depreciation Machine No. 1		400
	1958 depreciation Machine No. 2		800
	1958 depreciation Machine No. 3		1600
	Total		$3200
	Bank loan	$2800	
1959 --	Depreciation	$2000	
12-31-59	Pay bank loan —		
	Apply 1959 depreciation Machine No. 2		$ 400
	Apply 1959 depreciation Machine No. 3		1200
	Apply 1959 depreciation Machine No. 4		2000
	Total		$3600
	Bank loan		2800
	Balance available for re-investment		$ 800
1960 --	Depreciation		$1600
1961 --	Depreciation		1200
1962 --	Depreciation		800
1963 --	Depreciation		400
	Total depreciation . .		$6000

Machines owned on January 1, 1954 — 1 New
Machines owned on January 1, 1955 — 1 New
1 1 year old

Machines owned on January 1, 1957 —	1	New
	1	2 years old
	1	3 years old
Machines owned on January 1,1959 —	1	New
	1	2 years old
	1	4 years old
	1	retired

Under the previously described Re-investment of Capital Investment Plan, the original investment of $6000 in one new machine on January 1, 1954, has made available for use 3 machines on January 1, 1957 — 1 new, 1 two years old and 1 three years old. The money required to purchase the 2 additional machines came from depreciation allowances and bank loans. If the bank loans were repaid in monthly installments, then by using depreciation allowances the loan on Machine No. 2 was paid in less than 14 months and the loan on Machine No. 3 was paid in less than 12 months.

The preceding example of the Re-investment of Capital Investment Plan shows clearly that the liberalized methods of depreciation under the 1954 Code do afford companies in the construction and allied businesses to own modern labor saving machines for more profitable operations at a relatively low cost and without using additional cash for capital investment.

Customer Has the Down Payment

Bank Loan for Balance to be Paid in Installment Payments. Suppose a contractor wants to buy a new piece of equipment but has available only sufficient cash to make a down payment of 25 per cent and his bank agrees to finance the balance on the basis of 30 monthly installments plus an interest rate of 5 per cent per annum on the unpaid balance each month.

Piece of equipment — Cost	$6000
Down payment — 25 per cent	1500
Bank loan	$4500
Monthly installments (30 months) . . .	$ 150 each plus interest
Useful life of equipment	5 years

Consider in this case only the application of payments against the loan (see interest cost below) and that the piece of equipment has no salvage value at the end of five years.

Let us review the cash investment of the contractor and how he can make his installment payments by using the depreciation allowances under the liberalized methods of depreciation.

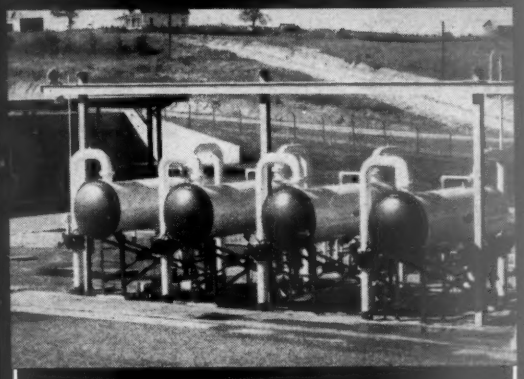
Cash Recovery Through Depreciation

Year	Cash investment	Installment payments	(Example 1) Straight line	(Example 2) Declining balance	(Example 2A) Declining Bal. and Str. line	(Example 3) Sum of the years — digits
1st . .	$1500					
	1800	$1800	$1200	$2400	$2400	$2000
	3300	1800	1200	2400	2400	2000
2nd . .	1800	1800	1200	1440	1440	1600
	5100	3600	2400	3840	3840	3600
3rd . .	900	900	1200	864	864	1200
	6000	4500	3600	4704	4704	4800
4th . .	—	—	1200	518	648	800
	6000	—	4800	5222	5352	5600
5th . .	—	—	1200	311	648	400
	6000	—	6000	5533	6000	6000

The interest at the time of the first installment payment is $18.75, and the interest at the time of subsequent installment payment is reduced each month by $0.625. Total interest for the 30 months is $290.63.

Any action taken by an owner of depreciable equipment must be taken after carefully reviewing Section 167 of the 1954 Code and the regulations thereto issued by the Commissioner of Internal Revenue. This review in no way shall be used as a substitute for the Code and the regulations. *

STILL THE BEST WAY
to remove water and solids from products pipe lines . . .



EXCEL-SO
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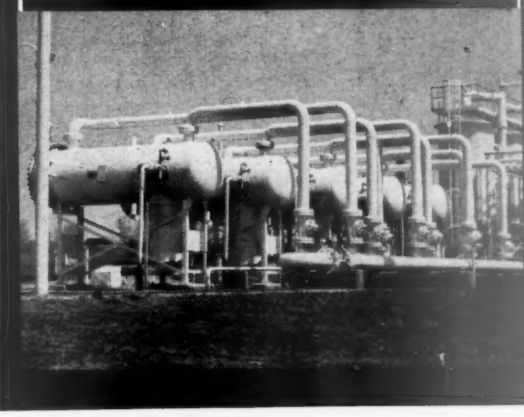

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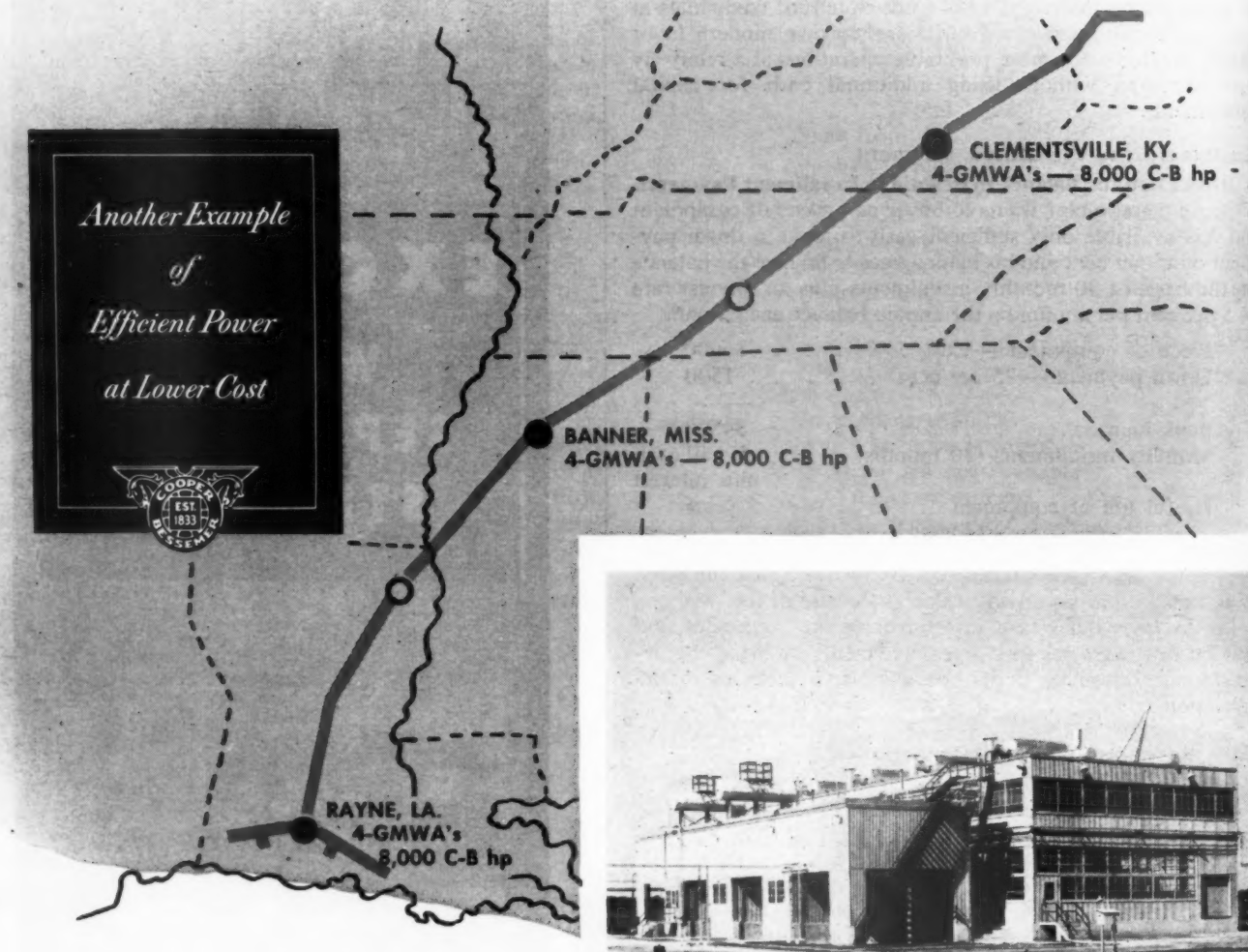


● Main compressor building of the 8,000 hp Cooper-Bessemer powered Rayne station.

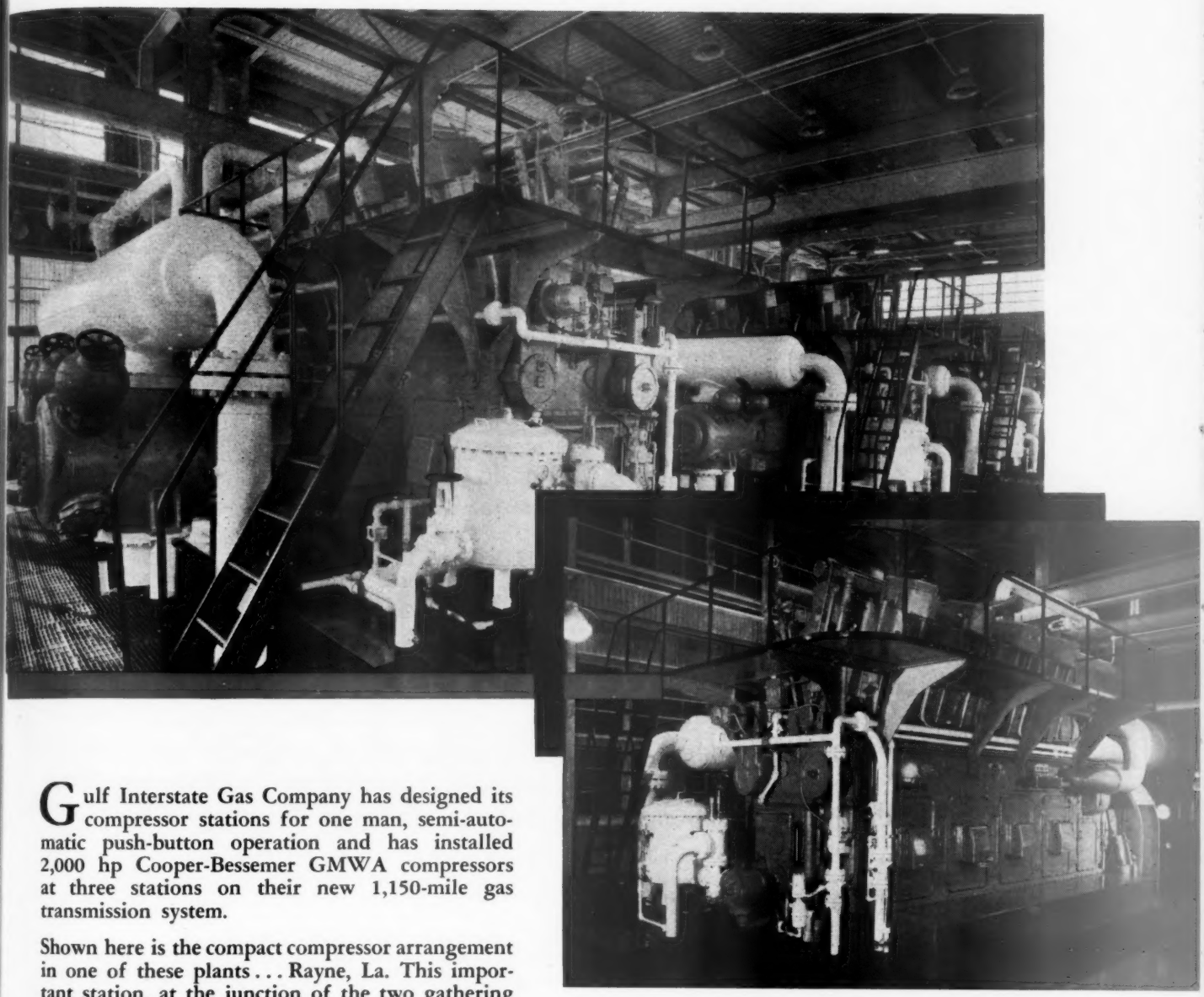
ANGLE

Compressors

New York Washington, D. C. Bradford, Pa.

San Francisco, Cal. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash.

● **Shown here from the compressor cylinder side are four of the GMWA compressors used in Gulf Interstate's transmission of natural gas from fields in southern Louisiana to West Virginia.**



Gulf Interstate Gas Company has designed its compressor stations for one man, semi-automatic push-button operation and has installed 2,000 hp Cooper-Bessemer GMWA compressors at three stations on their new 1,150-mile gas transmission system.

Shown here is the compact compressor arrangement in one of these plants . . . Rayne, La. This important station, at the junction of the two gathering laterals and mainline starting point, is equipped with four 8-cylinder GMWA units, identical to those in the Banner and Clementsville stations. Each of these Cooper-Bessemer installations offers top automatic operating efficiency without sacrificing flexibility.

Helping push natural gas to the northeast, these dependable Cooper-Bessemer units can be relied upon to deliver continuous top availability, low operating expense, unmatched compressor flexibility and minimum maintenance demands.

● **Line-up of four Cooper-Bessemer 2000 hp GMWA V-angle units in Gulf Interstate's Rayne, La. station.**

All the latest Cooper-Bessemer V-angles . . . GMXA's, GMVA's, GMWA's . . . are ready to help *you* cut costs on heavy-duty compressor requirements from 200 to 3000 hp. For further information, contact the Cooper-Bessemer office nearest you.

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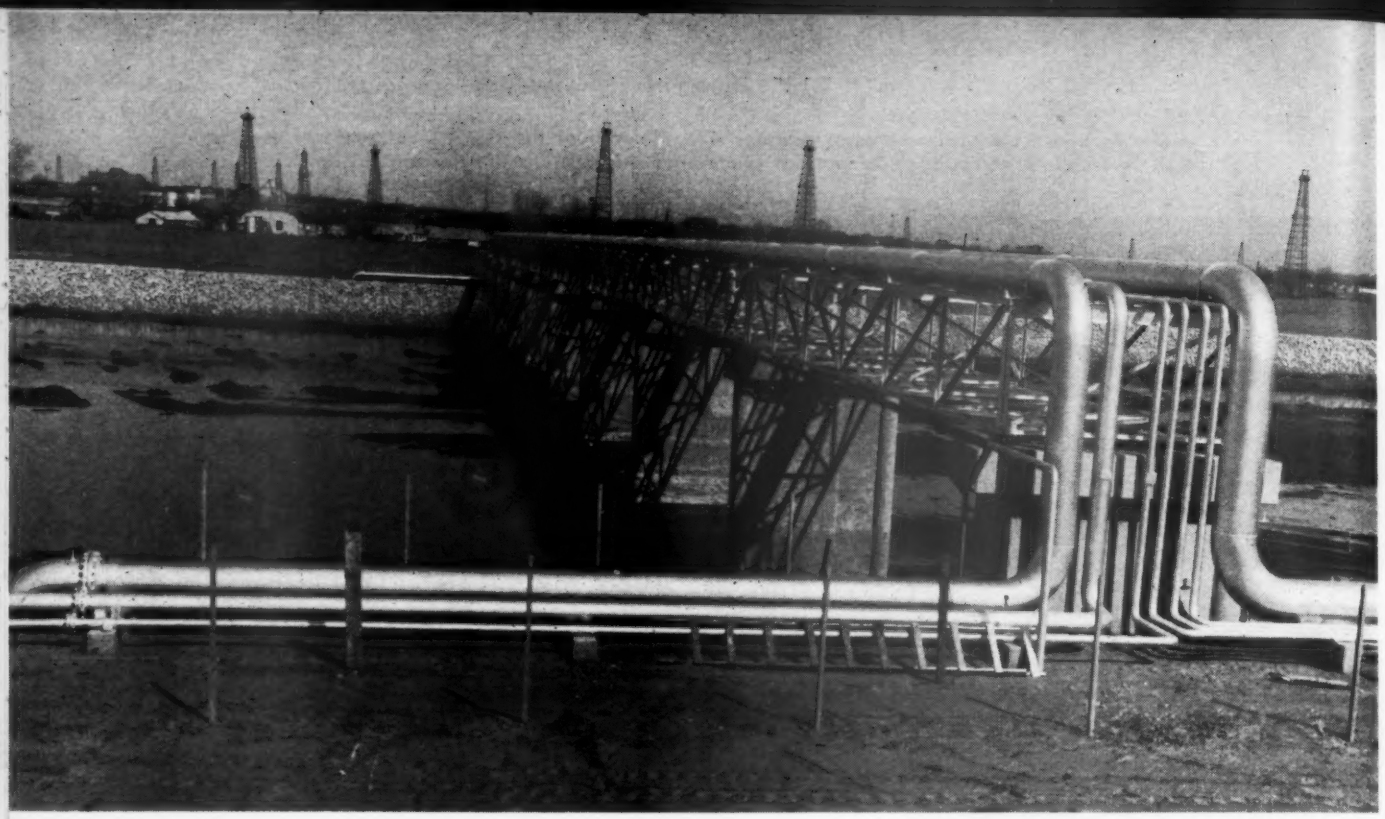


▲ One of the multiple-line crossings constructed across the floodway. This one carries seven lines

P 615.371.

River Crossings in New Dress

Phillips engineers, municipal officials cooperate in consolidating 16 pipe line crossings of North Canadian River into three centrally-located bridge crossings in Oklahoma City

J. R. Sellers and S. J. Brady

COOPERATING WITH OKLAHOMA CITY, Oklahoma, in solving a portion of its problems connected with civic improvements, particularly Phase II of the Oklahoma City Floodway Project, Phillips Petroleum Company recently completed the relocation of certain facilities along the North Canadian River.

The project was the result, in part, of the $50,000,000 bond issues voted by Oklahoma City in 1950 and 1953. This particular phase of the bond issue expenditure involved the problem of realignment and widening the North Canadian River channel. Improvement of adjacent lands for highways and park developments was also included in the plans.

This area was formerly utilized as a refuse disposal grounds and contained many substandard houses located along the river's course.

Phillips Petroleum Company had a novel assignment, acting in the dual role of consulting engineers for Oklahoma City and of an owner for the relocation of its own facilities.

One of the problems encountered by the engineers in the development was the relocation of the numerous pipe line river crossings within the project area. City officials were of the opinion that the owners of the pipe lines could arrive at the most economical solution due to the possibility of consolidating the pipe lines and rerouting for multiple crossings at central locations. The majority of the pipe lines belonged to Phillips Petroleum Company; therefore, it was appointed as consulting engineer to design and supervise the construction of three bridges for pipe line crossings.

There were 16 lines in the area, ranging in size from 3- to 24-in. Products transported include water, gasoline, residue gas, vacuum gas, crude oil, and natural gasoline. All of these lines were constructed across the old river channel at different locations, some being above the stream on suspension bridges and the remainder being buried below the stream bed.

EXCLUSIVE

Multiple Crossings Most Economic

Various solutions were considered, but the most economical and feasible approach was to combine products where possible and reroute lines to three central points to provide one single-line crossing and two multiple-line crossings. With this plan, the city's desire to eliminate the problem of locating pipe lines during future maintenance excavations was achieved. Bridges, rather than underground crossings, were adopted because of economy, maintenance, and operations.

Cost estimates indicated that by making multiple pipe crossings on bridges, a savings could be effected as

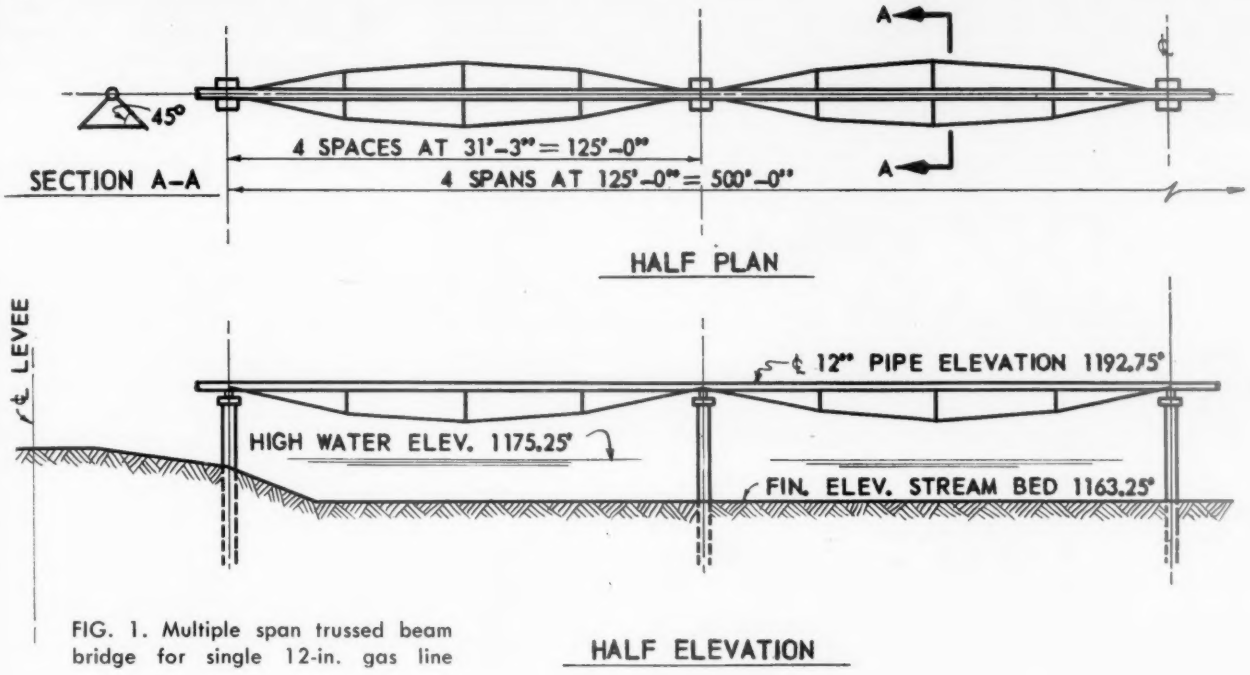


FIG. 1. Multiple span trussed beam bridge for single 12-in. gas line

compared to submarine crossings. Actual construction costs reflected a savings of approximately 30 per cent.

The planned park areas, adjacent to the river, dictated that any overhead river crossings be designed to blend into the overall scheme. Three types of bridges were considered, namely, conventional truss and pier, suspension, and trussed beam and pier. Cost estimates indicated that the truss and trussed beam type bridges would be the most economical. Fabrication and erection would be simple and the low silhouette of the bridges would harmonize well with the proposed park beautification.

Bridge Features

There were no new design concepts involved in the design of the bridges, however, there are no other known installations where a multiple span trussed beam pipe line bridge has been used. This bridge is shown in Fig. 1.

The trussed beam bridge supporting a single 12-in. natural gas line was designed as a simple span for the dead load and considered continuous for the wind and ice loads. Each span was erected individually and the cables tightened to provide the proper alignment and camber prior to the welding of the respecive ends.

Since all of the loads except ice and wind load were acting at the time of welding, there were no stresses due to dead load over the supports. After the adjoining spans were welded, any additional load would distribute the stresses as though the spans were continuous. To compensate for this additional stress, heavier sections of pipe were used over the supports.

The trusses shown in Fig. 2 were de-

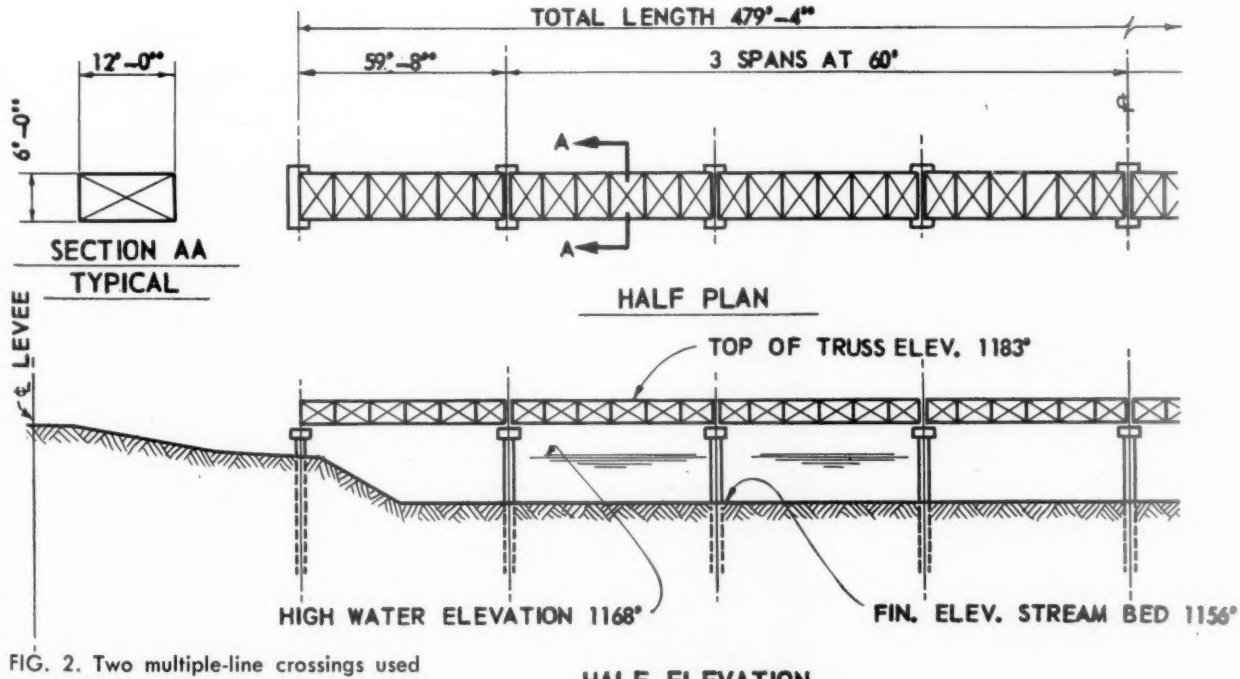
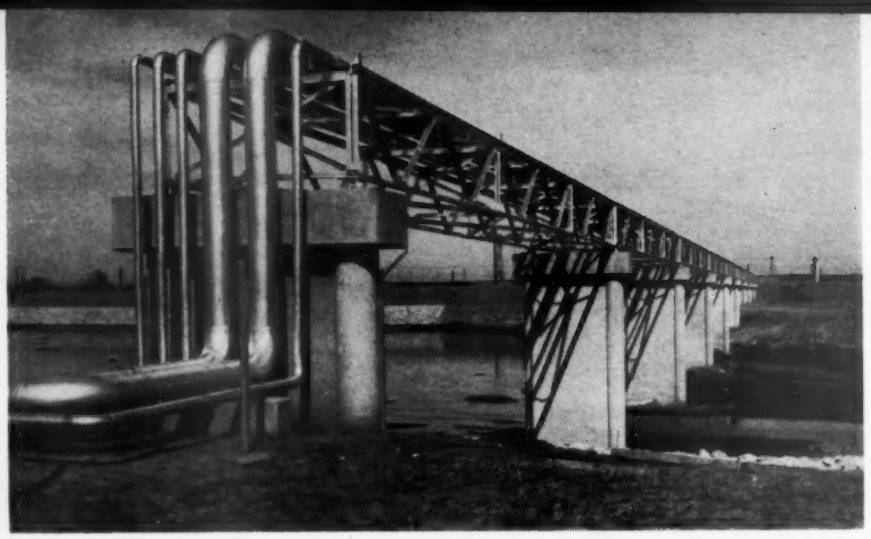


FIG. 2. Two multiple-line crossings used these simple truss spans, pin-connected



A total of 16 lines, ranging from 3 to 24-in., were rerouted, some combined. This bridge, one of three, carries six lines across the floodway

signed as simple, pin-connected spans, with the holes for the pins slotted at one end to provide for expansion and contraction. The trusses were cambered for the dead and product loads.

All of the pipes were continuous over the entire length of the bridge. Expansion bends were provided at each end and the pipes were firmly anchored at the midstream pier to assure proper stress distribution.

Pier Construction

Each concrete pier was supported on two 10-in. diameter pipe piles which extended six inches into the concrete cap at the top of the pier. Each pile was driven full length with a steam hammer to a bearing of 25 tons or greater.

The piles are protected with a 6-in. covering of concrete which extends three feet below the stream bed. An 8-in., poured in place, reinforced concrete diaphragm connects the two piles and also serves to prevent floating debris from lodging between them.

Combination steel and wood slip forms were used for the piers and diaphragms. Each pier required three separate pours. The interior of the pipe pile was filled with concrete to a minimum of five feet below finished stream bed elevations. All of the concrete above finished grade was given a rubbed finish.

Shop-Fabricated Trusses

All of the trusses for the multiple pipe line bridges were shop-fabricated and, where terrain would permit, the entire span, consisting of two trusses, cross bracing, etc., was erected on the ground and hoisted into place.

The Authors

J. Robert Sellers

Stanley J. Brady

Stanley J. Brady joined Phillips Petroleum Company's engineering department in 1944, and has been engaged in pipe line construction in the Mid-Continent area for eleven years. He was appointed general pipe line construction superintendent in 1954.

J. Robert Sellers received his BS degree in civil engineering from Oklahoma A&M College in 1948. He joined Phillips Petroleum Company's Engineering department immediately following graduation. For the past seven years he has been engaged in the structural design of various facilities related to the petroleum and chemical industry and is supervising structural design engineer.

Erection of the trussed beam spans required close coordination between equipment operators. Each span was assembled on the ground with the struts and cables above the 12-in. pipe (rotated 180 deg from normal position).

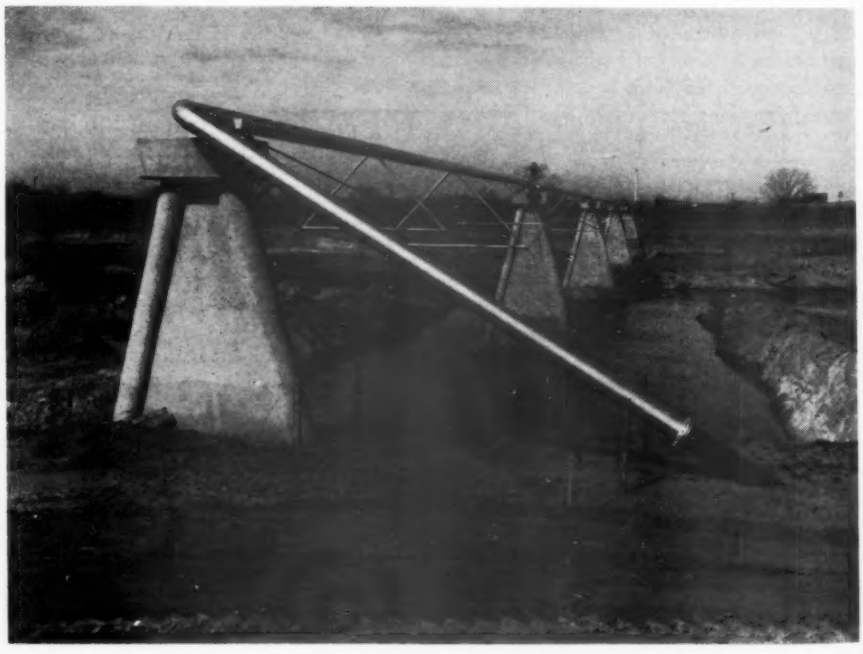
After the cables were tightened, the span was turned over. Rotating the fabricated span to normal position, after fabrication, involved providing adequate support at the center as the trussed beam was turned. Otherwise, excessive bending would occur in the pipe since the cables will not take a compression load. Three cranes, one at each end and one at the center, lifted the span and at the same time revolved the trussed beam. The two end cranes then placed the span on the bridge piers.

All of the bridge steel and pipe lines were given one coat of metal primer and two coats of aluminum paint. The end piers and pipings were fenced to discourage trespass on the bridges.

Acknowledgments

J. R. Sellers, design project engineer, S. J. Brady, pipe line construction superintendent, and F. E. Routson, construction superintendent, all of Phillips Petroleum Company, were responsible for the design and construction. W. W. Baker, city engineer, and Carter G. Dudley, assistant municipal counselor, were advisors for the City of Oklahoma City. Steelman Construction Company was the general contractor.

* * *



Only one of the three bridges carries a single line, a 12-in. natural gas line. This is a trussed beam design

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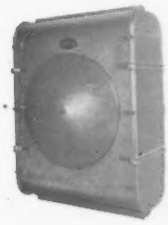
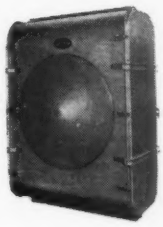


PIPELINE BOOSTER STATIONS



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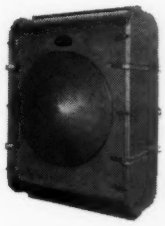

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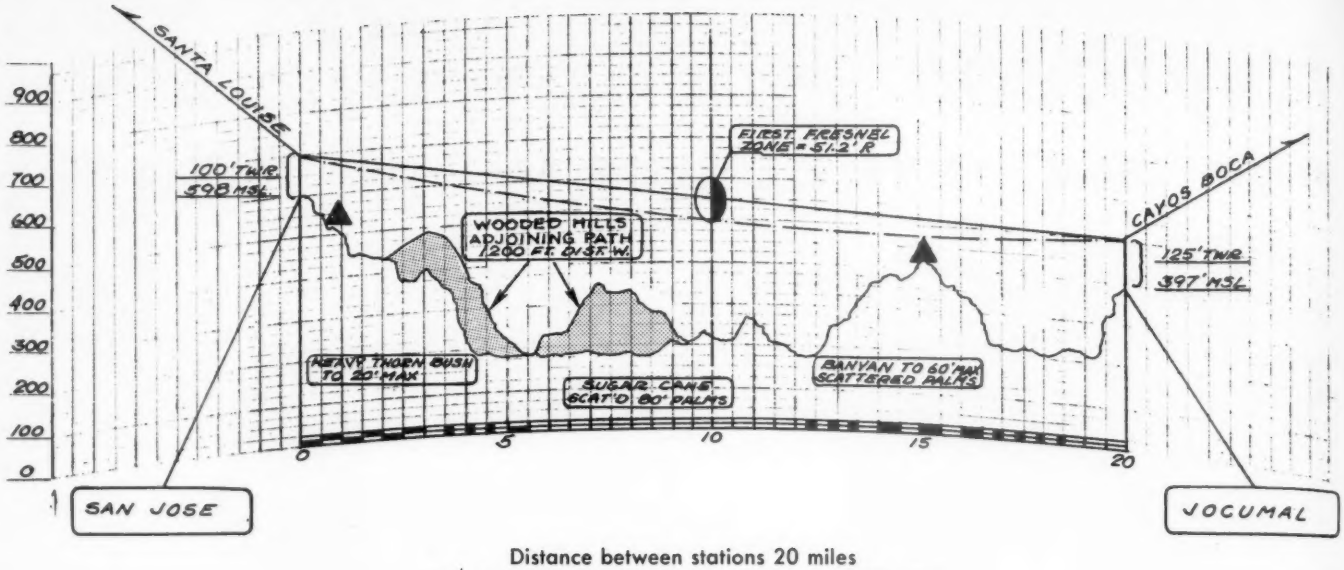


Distance between stations 20 miles
Curvature based on earth radius 4/3 × 3957 miles

RADAR PROFILING

An economic and flexible method for determining microwave system paths

W. C. Eddy

ONE OF THE MAJOR REQUIREMENTS in the design of any satisfactory microwave system is the early determination of the paths that will be used in propogation of the signal from tower to tower. The art of selecting such paths, anticipating the tower heights that will be required and reporting on the characteristics of the terrain between terminals, is known as *microwave surveying*. The portrayal of the terrain in terms of a graph, from which data pertinent to the propogation of the signal can be obtained, is termed *profiling*.

These two functions are both of prime importance in the design of any communication system lying in the microwave spectrum, yet strangely enough this art of path analysis has lagged behind the development of both equipment and techniques. Introduction of modern methods for obtaining satisfactory data over proposed paths with speed, economy, and unassailable accuracy was the product of post-war research and equipment and only now has succeeded in proving itself through the successful operation of many major systems originally designed from surveys made by this method.

Before discussing the advantages that have been demonstrated by the aerial microwave survey equipment, it is well to review quickly the specifications for the various data that must be collected and reported on by any method of survey if the design engineer is to have before him all of the material required in designing a usable network.

Assuming that standard commercial equipment will be used in the generation and reception of the signal and that this particular equipment has been demonstrated to be relatively infallible in its operation, it remains only to select a suitable transmission path over satisfactory terrain, and with sufficient allowances for atmospheric conditions along the route to insure a workable system.

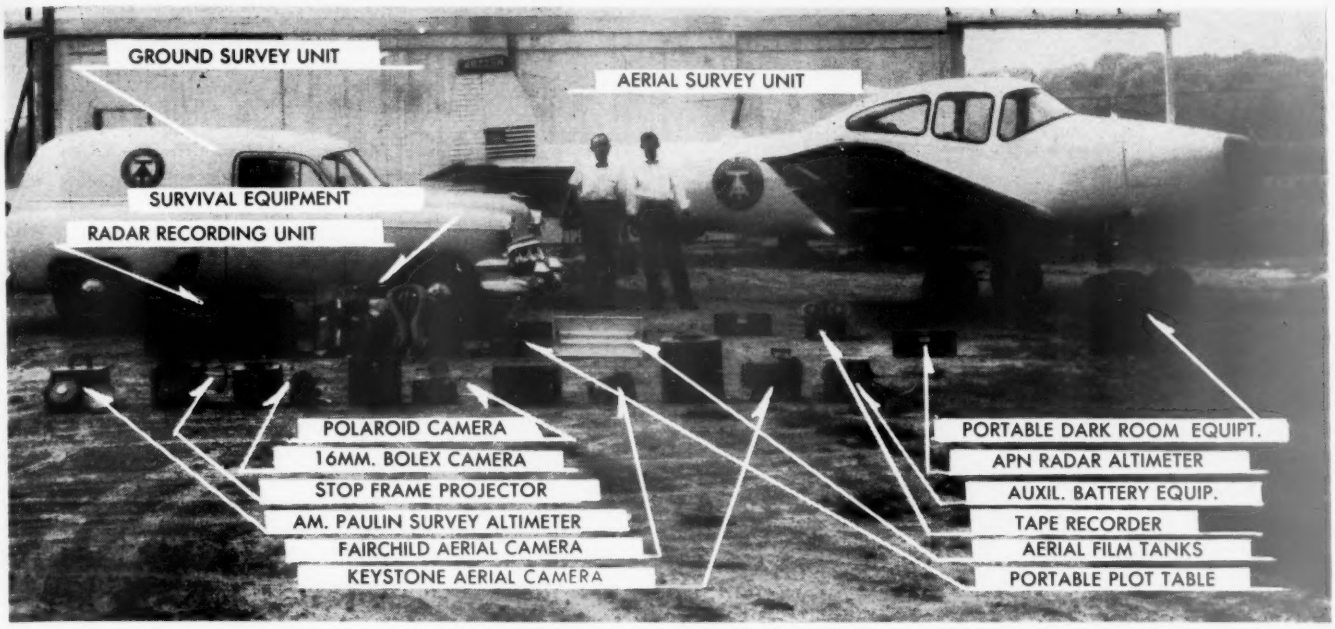
EXCLUSIVE

Accurate Data Needed

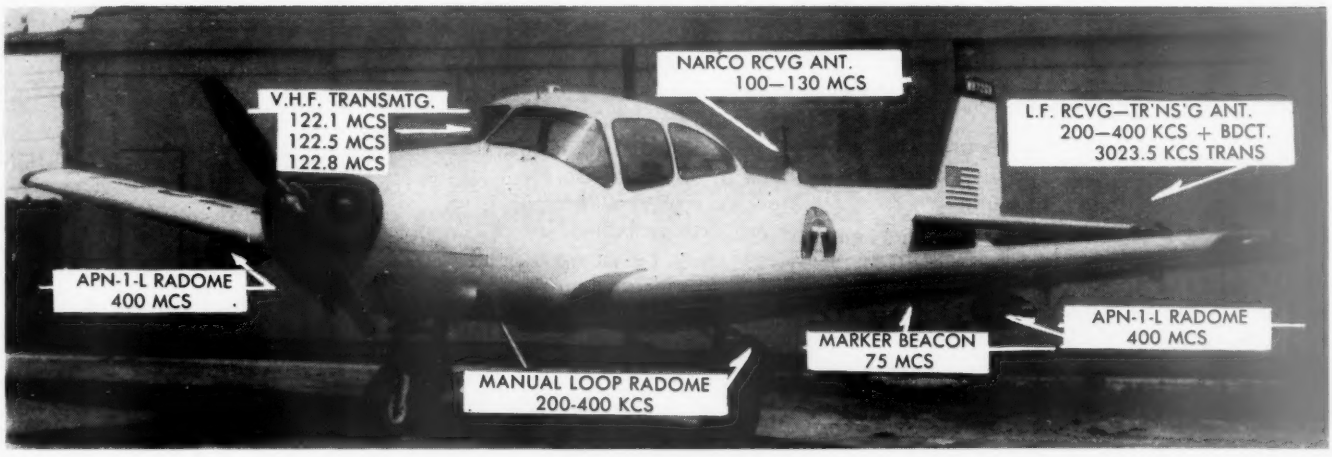
In order to satisfy this equation, design engineers must have accurate data on the following details:

1. The path length and the general atmospheric conditions that can be expected over and near this route.
2. An accurate . . . repeat ACCURATE . . . graph of the terrain elevations directly beneath the microwave path.
3. A complete study of the foliage along the path, especially in its

XUM



Aerial and ground survey equipment



Aerial survey equipment

relation to the high points in the profile.

4. An accurate description of the terminal sites with particular regard to their elevation above the mean sea level base lines, the ground conditions at the site, the availability of power and telephone service, and the all-weather accessibility of the location for maintenance purposes.
5. A complete description of the proposed path based on the propagation phenomena that may be expected during the various seasons.
6. A projected signal path detailing the width of the elliptical Fresnel zone of transmitted energy, as well as a computation of the possible effect on full use of this zone by reason of observed obstructions along the system.

Obviously, the preparation and assembly of such data is basically an engineering function, for from this material the blueprint of the system will be drawn. To err in the accuracy of the data or to fall short of a complete report will definitely jeopardize the future success of the link.

Too many times in the past this problem of path analysis has been considered a semi-necessary, but unimportant, part of the planning stage, a chore to be solved from questionable charts, or more often by the assumption after a casual appraisal that the path was "reasonably clear."

Several Survey Methods Possible

A survey of a microwave system can be accomplished in several different ways. If accurate and currently dated topographic charts of the area are available, a path projected from this data and carefully checked by reconnaissance from the ground, will normally produce the necessary data. This method is by far the most economical in areas where satisfactory **topographic charting** is available.

Unluckily, only an extremely small part of the United States has been so charted, a mere 25 per cent by latest report. The alternate use of outdated charts as a substitute for modern topos is obviously a meaningless economy that can well jeopardize the entire microwave investment by introducing error at the planning stage.

In the uncharted areas, which cover a major part of the country, it is necessary to develop the terrain details by means other than reference to charts.

The so-called **walking survey**, wherein a party of qualified observers traverse the path with survey equipment, is one of the alternate methods.

XUM

Survey plane over typical mountainous terrain

In some sections this approach is not only satisfactory from the engineering standpoint, but economical as well. In other sections it becomes a laborious project that produces only the most meager returns.

To meet the basic requirements of accuracy, economy, and speed in collecting data, the following conditions must exist if the walking survey is to be considered practical.

a. The terrain between the two stations being surveyed must be reasonably accessible, permitting the observation team to follow closely the proposed signal path.
b. Adequate bench marks must be located on or close to the path to permit easy establishment of terrain elevation along the route.
c. Qualified observers, preferably engineers trained in microwave propagation phenomena, must make up or supervise the walking survey team if the path is to be properly evaluated.
d. Means must be set up to insure that the survey team actually traverse the projected beam path and that the terrain details reported on are those lying *directly beneath* the proposed signal path.
e. Sufficient readings must be developed along the route so as to produce a profile that delineates all of the ground characteristics that will bear on the propagation formulae.
f. Inasmuch as the system design will rely on the accuracy of this data, a cross check or duplicate survey should be made as verification of the original readings.

If these conditions are known to exist and can be met, and the estimated time and cost of deriving information by this method is not out of line, the walking survey is entirely practical and should be employed. If the conditions above do not exist, resulting in insufficient or marginal data and high costs, or expensive delays, the more modern approaches from the air are recommended.

There have been many variations of ground survey proposed, tried, and either continued on a spasmodic basis or discarded because of their limitations or impractability.

Flashing lights from one terminal to the next is one of the earliest of these methods. The costs here are high, requiring temporary towers or fire trucks at each end to simulate the tower heights. In addition to the general impracticability and cost of transporting and erecting such equipment in rough terrain, the fact that the flashing lights are visible over the path during the instant of test are not conclusive in predicting that the microwave beam launched over the same path will continue to operate throughout all seasons of the year.

Because of the phenomena of refraction that may exist at the time of observation, the line of sight may actually bend around the earth to disclose objects below the real horizon, a condition that is not uncommon over the Great Lakes and other large bodies of water under certain frontal conditions.

If the system were, by chance, designed on the basis of such an abnormal condition, the microwave path would obviously be adversely affected when conditions returned to normalcy. If, however, the flashing light technique is elected and is used with full realization of the variables that may occur, this technique will prove only that the path is unobstructed and nothing else, unless a walking survey with all its complications is added to the process.

Test transmissions over sample paths is another approach to the problem of proving the final acceptability of a system. This is an extremely expensive method requiring temporary towers and sufficient test transmissions to explore the characteristic beam bending phenomena under various atmospheric and seasonal conditions. It does, when successfully carried out, prove without doubt that the path is clear and workable for the conditions of tower height, reflector diameter, and frequency used in the test.

There are two methods of **aerial surveying** in common use today, the *photogrammetric* (three-dimensional photographic analysis) and *radar profiling* (graphic analysis) of the path. Both rely on an airborne observation platform to solve the problem of inaccessibility of the terrain below. Both depend, on the other hand, on satisfactory flying and weather conditions over the route.

The **photogrammetric technique** is based on development of a three-dimensional strip photo of a given path, which photo is later translated in a laboratory into a topographic contour chart. The photography is normally done at altitudes and under light conditions that are similar to the requirements in standard aerial mapping. These conditions of light and cloudless days are reported to exist only 10 per

The Author

William Crawford Eddy is president and active manager of his own company, Television Associates, Inc., which was formed in 1948 to manufacture items on which he holds patents. He has also served as consultant in the design and construction of various new TV stations and several TV and microwave relay networks.

The activities of Television Associates have been expanded in the past several years to inculde work in the audio-visual field. The company is now manufacturing many of the devices which Eddy originated in this field, including the continuous film and tape magazines; cartridge loads for the magazines, and rear projection screens.

Eddy, captain, USN (Retired), was graduated from Annapolis in 1926. Following military service, he worked with the Philadelphia Farnsworth organization for three years and later joined the staff of NBC television. In 1940, Eddy built a TV station in Chicago, Illinois, for Paramount Pictures and Balaban & Katz. During World War II Eddy headed Radio Chicago, the Navy's training program for radar technicians. Later he served WBKB, Chicago, as director of television.

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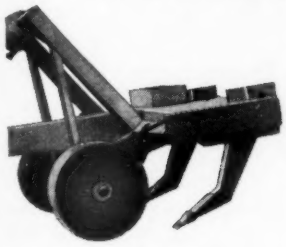

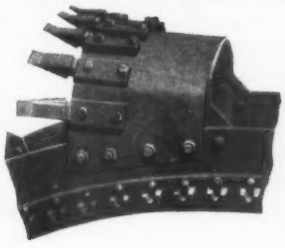

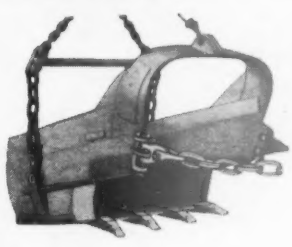

H&L TOOTH COMPANY

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cent of the time in the United States, a fact that may result in delays in assembling data.

The translation function, wherein the developed strip map is transformed into the required contour elevations, is a tedious process that may make the resultant profile somewhat costly.

A ground check and the establishment of reference bench marks are added requirements of this technique, which also may increase the cost and add to the delay in accumulation of data.

This approach does, however, produce a continuous vertical photograph of the path, clearly delineating the ground conditions in addition to supplying a highly accurate topographic contour map of the path. These two characteristics of the system are outstanding advantages not duplicated by other methods. If the path chosen for such treatment turns out to be clear of obstructions, the data developed by this aerial process and the accompanying ground check is sufficient to permit design work on the systems. If the path is found to be obstructed, the process must be repeated until a clear path is discovered.

The **radar profiling technique** is similar in approach but considerably more flexible than the photogrammetric system.

It does, like the photo system, require passable flying weather but is not limited to photographic conditions. These less stringent conditions are generally available some time during the day in all but zero weather.

Like the other aerial system, the radar profiling technique is unaffected by the inaccessibility of the terrain below, making it applicable in any area. Unlike either the ground survey or the photo survey, the radar profiling system actually flies along the projected beam path and makes its measurement from this most logical of altitudes.

The data collected along this path is transcribed on film and magnetic tape at plane speeds of approximately 120 mph. To verify the accuracy of the original profile, the original data is cross checked by repeating the measurement flight in reverse direction, using the composite curve as the true profile.

A ground check of the terminal sites is incorporated as part of the system, insuring bench mark accuracy along the entire path when it is transcribed to profile charts. Additional photographic substantiation of site locations and path obstructions is provided from several types of aerial photographic equipment carried in the plane.

Laboratory type test standards are employed in calibrating the radar equipment after the plane is in the air and are a part of the airborne equipment that permits the plane crew to make accurate profile readings independent of changes in the atmospheric pressure gradients along the path.

Piloting techniques have been developed that not only permit but insure that the plane follows the prescribed beam path at all times and that the readings reported are those of the effective terrain directly below the path. From such an aerial observation platform, the several possible routes between any two points are easily and quickly explored during the reconnaissance flights that precede measurement runs. The data collected can be immediately translated into rough but usable graphs permitting analysis and approval of the day's work before moving equipment further afield. Under ideal conditions as many as 150 completed miles of profile can be produced by one crew in a day's time.

Because of these factors, plus the simplicity of the electronic approach, the cost of the service averages only $20 per reported route mile in the United States for a complete report.

Competent engineering consultant services by registered professional engineers fully qualified by experience in both building and operation of microwave systems is included as part of the service. Such services have recently been made available on a world-wide basis with overseas rates running slightly higher than those quoted for the United States.

The type of airplane used in these surveys varies with the requirements of the job. Because of the hazardous altitudes at which the measurements are taken, each plane is "beefed up" for possible crash landings. The crew is equipped with crash helmets, safety belts, and survival equipment to increase the limited margin of safety in this work.

Special wing tip gas cells are used to provide additional stability in low level flight as well as increased operational range. All electronic and photographic recording equipment is custom-designed for the assignment. Two pilots with long experience in low level operation comprise the flight crew, in addition to a field representative responsible for assembling collected data. * *

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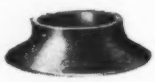

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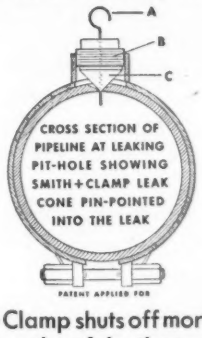
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Communications System Designed For *Automation*

Sy Orlofsky

▲ Transmission department supervisors at Houston take advantage of a special microphone and speaker unit (arrows) connected to the full period circuit to carry on a two-way conversation with one of Gulf Interstate's field superintendents.

GULF INTERSTATE GAS COMPANY'S 1160-mile pipe line system incorporates a new approach by gas transmission management to the important problem of obtaining adequate and dependable communication service. This approach is represented by a lease arrangement with the Bell System as contrasted to the more commonly practiced ownership by similar companies of private communications facilities.

Effective and reliable communications are absolutely essential to maintain the high degree of efficiency that has been built into Gulf Interstate's $130,000,000 system. Placed in service November 1, 1954, this pipe line represents the closest approach to automatic operation yet achieved by a large natural gas transmission system. With this overall emphasis on automation, the importance of the company's communications facilities cannot be overemphasized.

EXCLUSIVE

This is the first of two articles describing the communications system employed by Gulf Interstate Gas Company, newest of the nation's major natural gas transmission firms. This article covers the leased telephone and teletype facilities, and VHF radio equipment. A second article, describing in detail a new telemetering system installed by Gulf Interstate, will appear in the June issue of The Petroleum Engineer, Oil . . . Gas . . . Products Pipelining Edition.

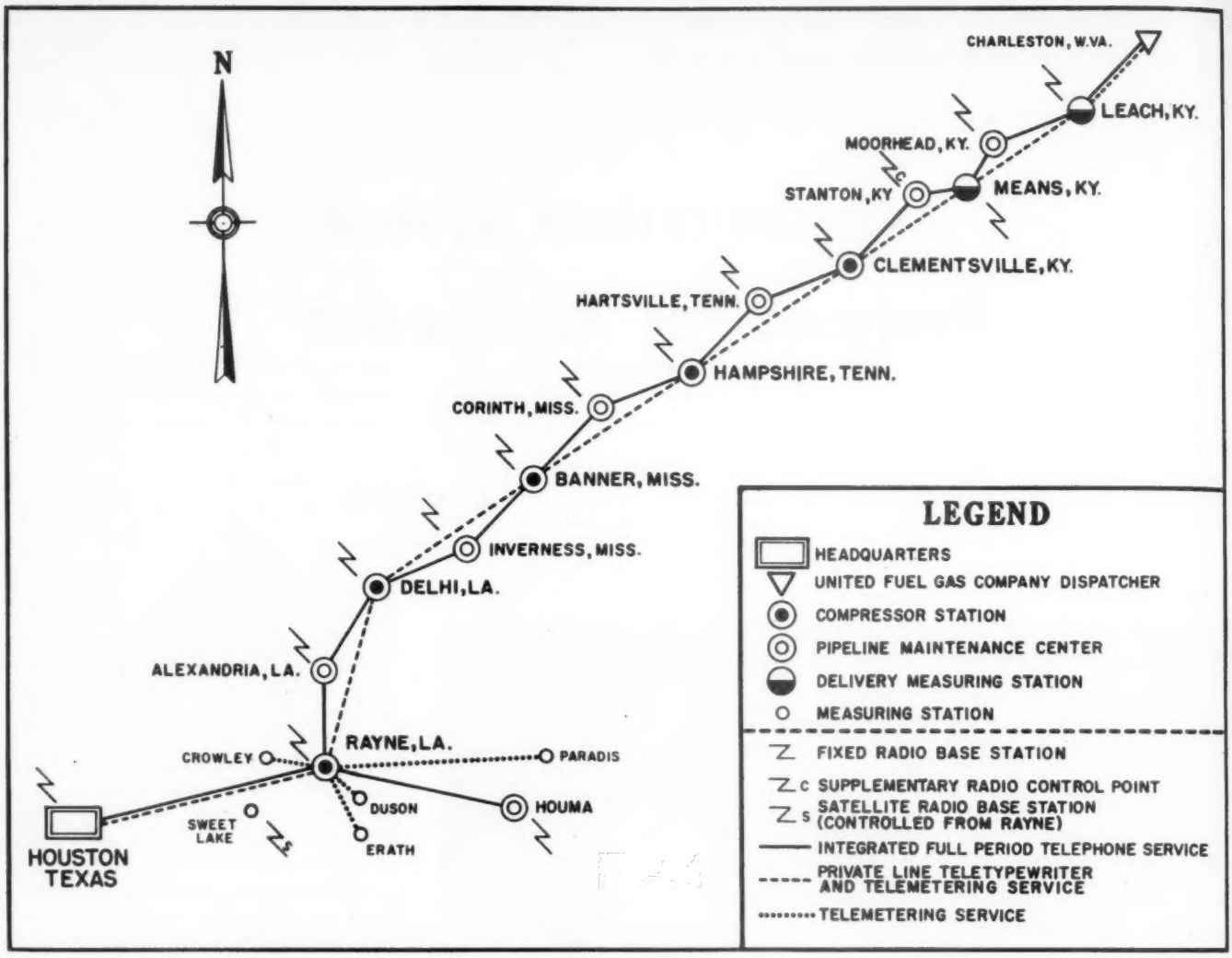

FIG. 1. A communications system embracing VHF radio, private telephone line, teletypewriter circuit and telemetering links Gulf headquarters with key points on its 1160-mile pipe line, plus a dispatching office in Charleston, West Virginia, of the United Fuel Gas Company, which routes delivery of the throughput from Gulf Interstate's new system.

In every phase of design and operation, Gulf Interstate engineers have sought to provide a pipe line that could transport natural gas the most economical way possible. The company's existing facilities are committed to delivery of 375,000,000 cu ft of gas daily to the Columbia Gas System, Inc., with an expected increase in daily capacity of 575,000,000 cu ft likely to take place in the near future.

Gulf Interstate's Communications Facilities

Briefly, Gulf Interstate's communications facilities provide:

(a) A full-time telephone circuit connecting 15 key points on the pipe line and the Houston, Texas, office.

(b) A VHF radio system with 15 fixed base stations, 4 portable base stations, 61 mobile units, and 24 hand-talkies.

(c) A teletypewriter circuit covering 5 compressor stations; a measuring station at Leach, Kentucky; Houston headquarters; and Charleston, West Virginia, dispatch locations for United Fuel Gas Company, a Columbia subsidiary that receives all gas transported by Gulf Interstate.

(d) A telemetering system linking the 5 compressor stations, 6 measuring stations, and Houston office.

The principal components of this communications system are provided through a lease arrangement with the Bell System. This has resulted in a flexibility, dependability and economy difficult to achieve in a privately-owned communications system. The decision to lease services from the telephone company was made for a number of reasons, including the following:

Why Leased Facilities?

(1) It is believed that telephone company communications facilities can be provided at a lower annual cost than a comparable, privately-owned installation.

(2) The leased installation requires a minimum investment.

(3) Greater flexibility is possible as a result of an arrangement with Bell, which can modify, expand, or contract Gulf Interstate's facilities as requirements change.

(4) Gulf Interstate is assured greater continuity than its experience indicated could be expected from a privately-owned system. Dependable communications are particularly significant to Gulf Interstate since its main line system consists of a single 30-in. artery extending some 850 miles. Any interruption in service would pose a serious threat to this important

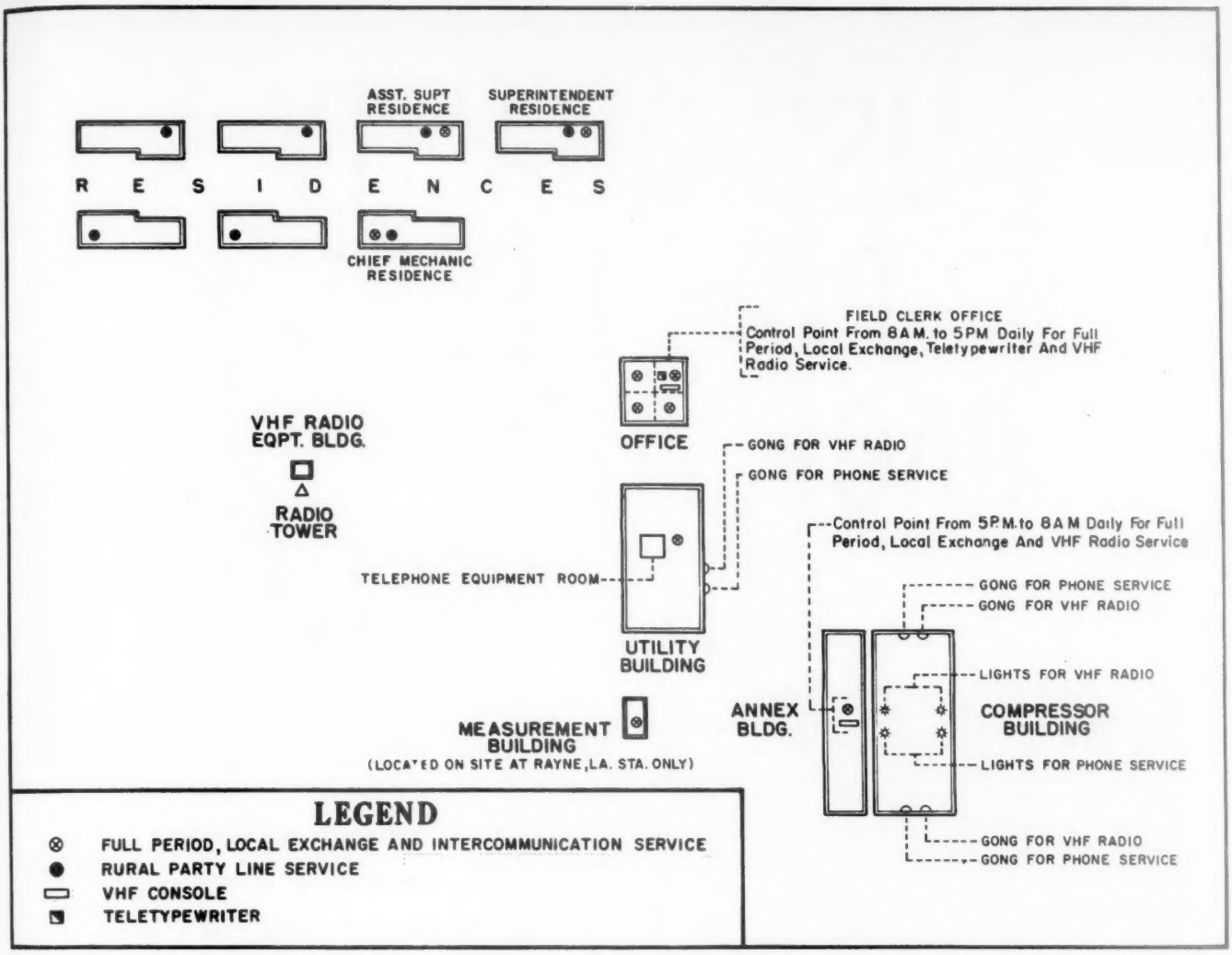
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FIG. 2. Communications facilities at each of Gulf Interstate's five main line compressor stations permit round-the-clock contact with operating personnel at remote points in the 40-acre installation. A system of lights and gongs provides notice to the operator on duty of incoming telephone and radio calls during other than regular business hours. Diagram shows typical communications facilities, but is not a scale drawing.

gas supply. The telephone company's communications network affords the opportunity of re-routing the leased circuits around any trouble spot should the need arise.

(5) A privately-owned system poses the problem of administering a communications department necessary to maintain the extensive facilities required. This is eliminated by Gulf Interstate's arrangement with Bell.

(6) Accounting problems are simplified since communications costs are billed monthly at a fixed rate.

(7) Bell's resources of experience, technical know-how, and trained personnel have been placed at our disposal to maintain a communications system equal to the advanced pipe line operations developed by Gulf Interstate. The telephone company operates 11 mobile maintenance centers adjacent to Gulf's pipe line to supplement the service available at its permanent stations. A repairman is never more than a few minutes distant from any of the locations. Gulf has been able to maintain a high degree of operating efficiency in all communications facilities since the start of operations. At the same time, Bell laboratories are conducting research designed to improve the equipment available to Gulf.

Just what are the features of the communications system installed by Gulf Interstate and in what manner do they improve operating efficiency? Each communication channel will be discussed separately, although there is necessarily some overlap in their functions (Fig. 1).

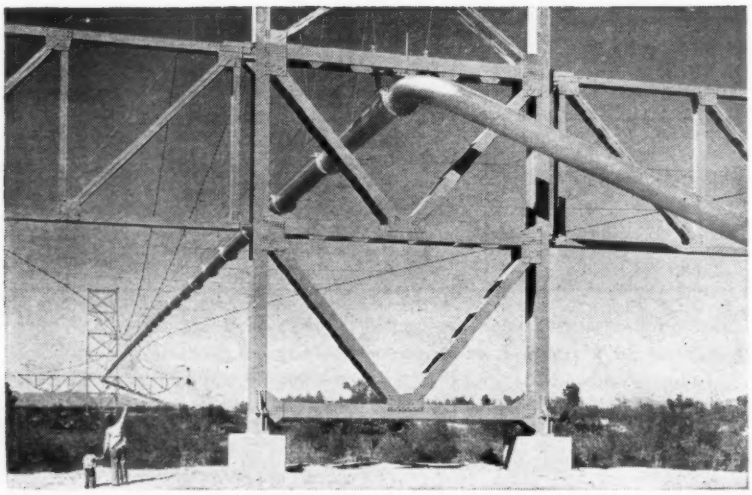
Full Period Telephone Circuit

A leased telephone circuit connects Houston with all key points along the 1160-mile pipe line system, plus United Fuel's dispatch office at Charleston, West Virginia. This entire circuit is engineered for conference service, which means that a conference call involving several stations on the circuit at the same time can be handled without a drop in voice volume. A special microphone and speaker unit is installed in the transmission department at Houston that enables any number of supervisory employees to gather in an office and carry on a two-way discussion with one or more field locations.

All telephone instruments are six-button key sets, making it possible to have local business service as well as intercommunications facilities and the private circuits all work through the same instrument. One button is used for "holding" calls and one is reserved for the time when a second private line may be required.

FROM NEW "HUB OF THE WEST" SOURCE...

USS QUALITY PIPE KEEPS PACE WITH THE WEST



Consolidated Western's new plant serves the entire West with Gas and Oil Pipe

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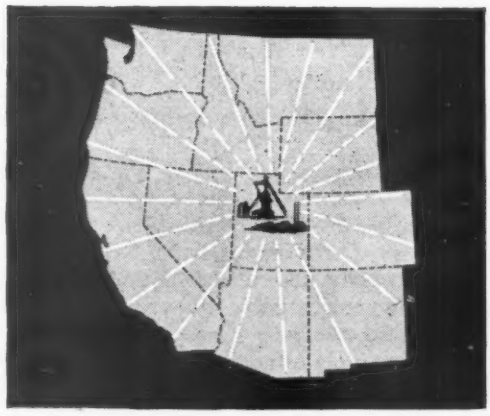
Because United States Steel emphasizes quality control from mine to mill to finished steel . . . its high-quality steel pipe is in demand the world over. A major portion of the world's large-diameter welded steel gas and oil pipe has been produced by the Consolidated Western process. For 100 years, Consolidated Western Steel has pioneered the fabrication, erection and manufacture of pipe, structural steel, plate products and mechanical equipment—constantly proving that only steel can do so many jobs so well.



The new plant at Provo, Utah is ideally located to serve you with the greatest possible efficiency. It will produce and deliver the highest quality electric-welded steel pipe at the lowest possible cost. Sizes available include 4" to 40" diameters to meet the needs of transmission pipelines, distribution systems and industrial installations.

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USS TRADE MARK

Gulf Interstate's VHF radio network includes 15 base stations, four portable stations, 61 mobile units and 24 portable hand-talkies, all of which can be integrated with the company's leased telephone circuit. Field personnel rely heavily on radio communications.

change lines are maintained at the field clerk's office. After daytime working hours, control of the circuit is switched to the annex building and to one of the supervisor's homes (Fig. 2).

An added feature of the leased telephone circuit is found at the compressor stations, where round-the-clock operations are maintained with a minimum of manpower. A system of strategically located signal lights and gongs notify the station operator of incoming phone and radio calls. Should the attendant at any time fail to respond to a phone call it can be answered at the residence of the supervisor in charge for that particular evening. A key in his residence is thrown during the in-charge period so that all incoming phone signals ring at that location as well.

Located at intervals between Gulf Interstate's present compressor stations are seven pipe line maintenance locations, five of which are scheduled to be future compressor station sites when it becomes necessary to add horsepower to increase throughput of the pipe line. Until these additional stations are built, the intermediate locations are being served with a single drop on the private circuit. A key button instrument ac-

The transmittal of messages on Gulf Interstate's teletype circuit is expedited by the use of automatic tape cutters, which permit the operator to verify accuracy of typing before placing tape on machine for rapid sending.

Any point on the full period circuit may be called by dialing a five-digit number. A two-way signalling system is available between different instruments at the same station or office.

At Houston, the leased circuit terminates in the PBX switchboard, enabling connection of the private line to any telephone at headquarters. During other than office hours, a key at the switchboard transfers all incoming calls on the circuit to the dispatcher's office. The dispatcher's telephone installation is so arranged that he can place outgoing calls on the full period line at any time without switchboard assistance.

At each compressor station there are nine instruments on the telephone circuit, except at Rayne, Louisiana, where a tenth drop has been added to cover the measurement building. Four of these drops are located in the station office—one each for the district superintendent, the assistant superintendent, the district clerk, and field clerk. Other telephone sets are located in the compressor annex building, the utility building and in the residence of the superintendent, assistant superintendent and chief mechanic. During regular business hours control of the full period and local ex-

commodates both the private line circuit and local business line.

VHF Radio System

Gulf Interstate's VHF radio system is as up-to-date as the push-button controls that operate the giant engines at the company's compressor stations. Consoles for operating VHF radio facilities at the compressor stations are located in the field clerk's offices and compressor annex buildings. At the pipe line maintenance locations the consoles are located in the field clerk's office, while at Houston the console is positioned in the dispatcher's room.

During business hours, control of the compressor station radio is maintained in the field clerk's office. After business hours, throwing a key transfers control of the base station to the console in the annex building where it is more convenient to the signal operator attending the station during the 4 p.m. to 12 midnight and midnight to 8 a.m. shifts.

The large number of 60-watt mobile radios are seldom out of touch with one of the base stations. These 61 units are installed in cars and trucks used by field personnel. With extensive territories to cover and a costly investment to maintain, these men rely heavily on radio communications.

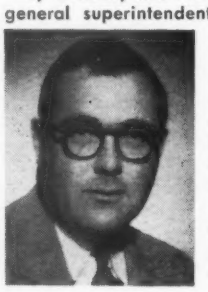
An important feature of the VHF radio system is its integration with the leased telephone circuit. This permits direct communications from an isolated mobile unit to any point on the full period hookup. Similarly, any point on the telephone circuit can be connected through the proper base station to any mobile unit.

The integration of radio and telephone channels is proving invaluable in the operation of Gulf Interstate's pipe line system. It affords direct contact between key personnel wherever they may be, along the line or at Houston headquarters. This eliminates critical delays in the relaying of instructions and information whether it be during normal operations or in an emergency situation.

Two company aircraft are equipped with VHF radio sets. This permits company officials traveling along the system to be in constant touch with their office and with all points on the pipe line. Similar units are also installed in the patrol plane operated by a flying service which covers Gulf Interstate's entire right-of-way. When the patrol pilot detects a leak, wash-out, or other hazard he radios the location and description of the trouble to the nearest base station, from where maintenance crews can be dispatched in a matter of minutes should the difficulty warrant immediate action.

Four portable 60-watt base stations are proving particularly useful in affording necessary communications at points of major construction activity. Supplementing these units are 24 Heimark portable hand-talkies, which have been distributed along the system for use when contact is needed at locations inaccessible to vehicles. All mobile, fixed station, and portable base station

The Author



Sy Orlofsky has held the position of general superintendent of Gulf Interstate Gas Company's transmission department since the new pipe line firm was organized in 1953. Prior to that date he had eight years' experience in an engineering supervisory capacity with various natural gas pipe line companies.

Orlofsky is a native of White Plains, New York, and holds a BS degree in mechanical engineering from the Missouri School of Mines and Metallurgy at Rolla, Missouri.

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radio equipment is of General Electric manufacture.

Gulf Interstate's 15 base stations operate at a maximum power of 250 watts, which provides a normal range to mobile units operating at a distance of 40 miles in either direction along the route of the pipe line. Most stations have Andrews bi-directional antennas mounted atop 300-ft steel towers. Other stations use leased tower space and have antennas designed to cover the desired terrain.

Teletypewriter Circuit

Gulf Interstate's private line teletypewriter circuit permits instantaneous transmittal of written communications between field offices and Houston headquarters. This facility lightens the burden on the radio-telephone channels and reduces intra-company letter writing while providing a reliable method for relaying memoranda, reports, and other routine information. The fact that the teletype system delivers a written message is a great asset in these operations, where accuracy of information is exceedingly important.

At each compressor station the teletype machine located in the field clerk's office is equipped with a selective dial attachment. Dialing the proper five-digit code number puts any other or all locations on the circuit ready to receive copy.

In the dispatcher's office at Houston, the teletype dial has been replaced with a newly-developed push button selector unit. Instead of dialing a code number, the dispatcher simply pushes the proper button and the selected distant station is instantly on the circuit. This push button selector is a useful aid to the dispatcher, due to the necessity of his calling numerous points on the pipe line in rapid sequence. The device is equipped with an "override" button, that permits the dispatcher to block any other transmittal that might be in progress on the teletype circuit and obtain an immediate connection with another location.

Automatic tape cutters are attached to the teletype machines at each compressor station and at Houston, making it possible for the message to be punched out on tape and then transmitted automatically at maximum circuit speeds. In this manner the operator can be assured in advance that the transmission will be correct, while at the same time reducing circuit time that might be taken up by slow typing.

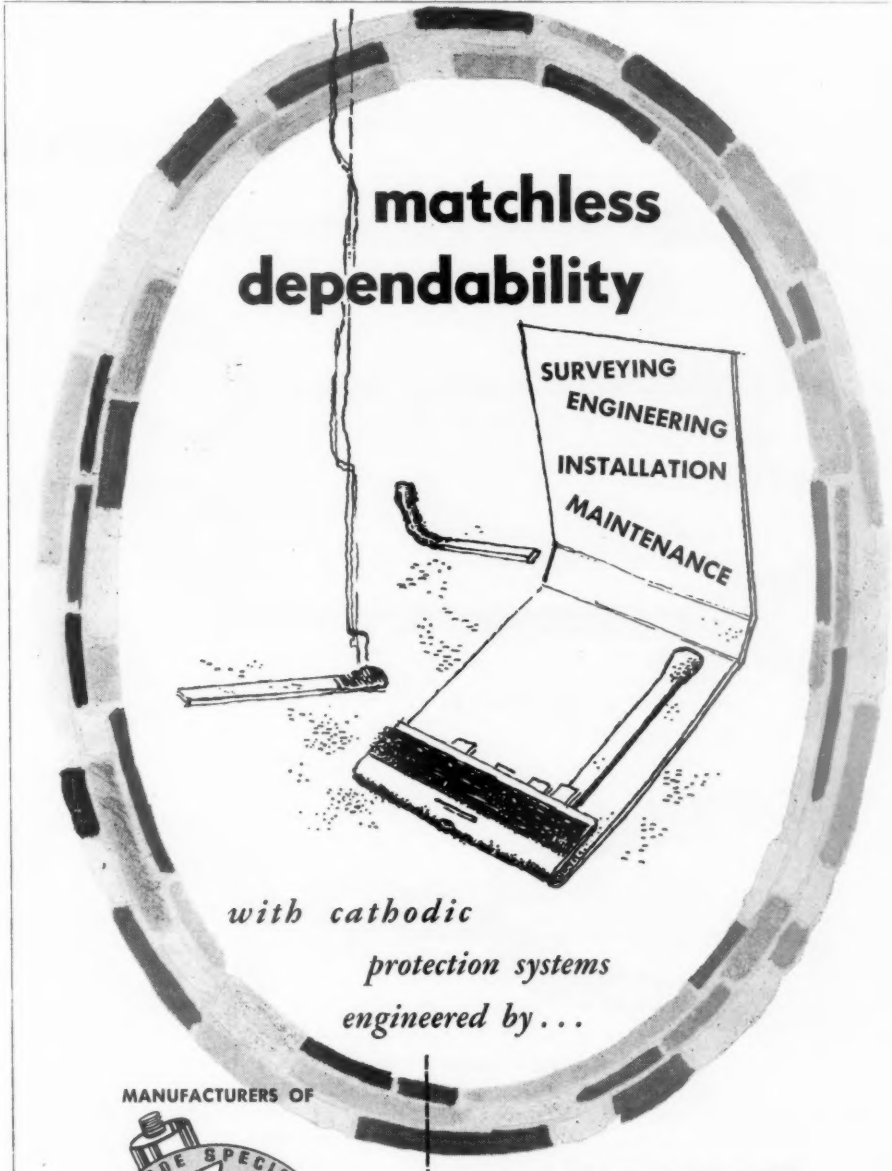
Telemetering System

Integrated into Gulf Interstate's teletype circuit is a newly-installed telemetering system, which represents a marked advance in telemetering techniques. In essence, the telemetering arrangement provides for the automatic transmission of vital operational data from key points on the pipe line to the Houston office.

The data is transmitted from a remote location on demand of the dispatcher, who simply pushes a selector button on his teletype machine in Houston to start transmission of the coded information. At a set time each hour the teletype circuit is cleared for the dispatcher to receive this telemetered data.

On demand—and without any action on the part of an employee at the distant location—the dispatcher can determine the engine speeds as well as suction and discharge pressures at any of the five compressor stations. In a similar manner he can establish the static and differential pressures and temperatures at any of the six measuring stations.

The telemetering system was developed jointly by engineers of Gulf Interstate, the telephone company and the Berkeley Instrument Company. A detailed article describing this system will appear in the June issue of *The Petroleum Engineer*. * * *



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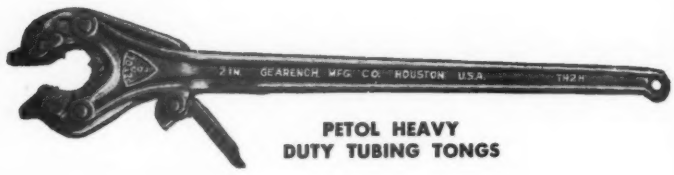

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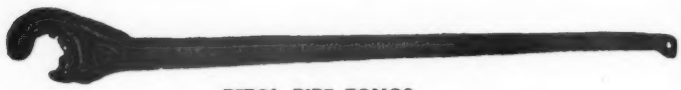

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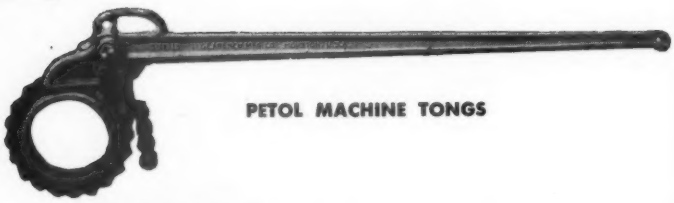

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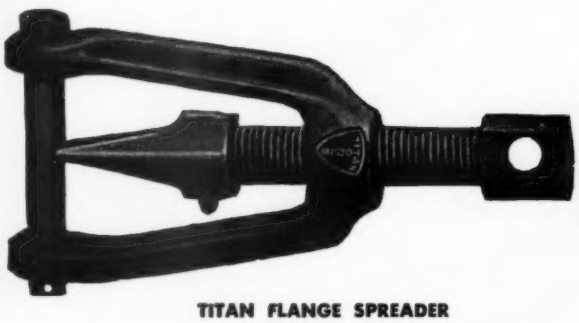

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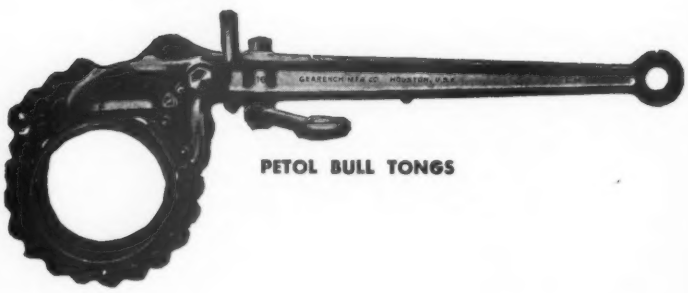

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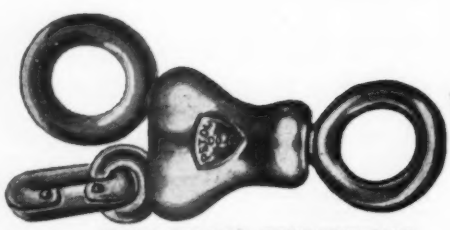

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P 629.25

Get more mileage from your dehydration operation . . .

Reclaim That Glycol!

. . . Recondition with economical heat-vacuum process

O. G. HOWE*

OPERATORS of some natural gas glycol dehydration plants are familiar with the glycol contamination problem and have taken steps to protect their operation, while others often are unaware of impending difficulties.

This article relates an experience that may be of assistance to other operators with similar glycol contamination problems.

● Manufacturer of some dehydration plants recommend the placing of separators, scrubbers, or other devices ahead of the dehydrator to control the condition of the gas reaching the dehydration plant. Individual installation studies often will allow the elimination of conditioning devices at installation time but the plant becomes vulnerable to contamination when operating conditions change.

A few contaminants that may be introduced, in the latter case, are pipe line dirt and dust, sand from well faces, drilling mud or any fluid that a connected well might produce, compressor station lubrication oil, and carry-over absorber oil from gasoline extraction plants.

● Continuous heating of the contaminated glycol solution in the regenerator causes a slow breakdown of the solution. This breakdown is greatly accelerated if the regenerative temperature approaches the boiling temperature of the glycol. This breakdown is accompanied by the formation of a black tarry sludge, which, either by itself or with other contaminants, has been known to plug flow lines and foul heat transfer surfaces to the extent of rendering the dehydration plant inoperative.

● At one of Oklahoma Natural Gas Company's dehydration plants, which did not have free water knockout protection, salt water was introduced into the glycol. As the water was boiled off in the regenerative cycle, the salt concentration became great enough to form deposits on the fire tubes of the direct-fired boiler. These deposits resulted in local overheating and set up stresses which caused a fire tube in the reboiler to rupture. In addition to the salt contamination a black oily sludge formed in the glycol, fouling pump valves, and causing excessive filter requirements.

To render the plant free of operational difficulties, due to salt and sludge contaminaton, two alternatives were available.

1. **To replace the contaminated with new glycol.**
2. **To recondition the contaminated glycol periodically.**

Replacement with new glycol was estimated to cost two and one-half times as much as reclamation, and, therefore, the second alternative was chosen. A company familiar with the problem was asked to build a vacuum distillation unit to reclaim the glycol.

● Various problems which necessitated changes in the reclaimer were encountered early during the reclaiming operations.

The incoming glycol was found to contain so much sludge and oil that a sufficient supply could not be introduced into the reclaimer without excessively frequent filter replacement, so filtering was eliminated. This made hand control of the filling of the still boiler necessary, because the sludge fouled the liquid level control.

It was found that a secondary accumulator accelerated operation, by permitting the reclaimed glycol to be drained off without losing vacuum on the system.

*Engineer, Oklahoma Natural Gas Company, Tulsa, Oklahoma.

EXCLUSIVE

Dark glycol in jar on left contains salt, oil, and sludge before reclaiming. Other jar contains clear, reclaimed glycol.

XUM

● The operation, as it finally developed, consisted of introducing fouled glycol into the still boiler and applying a vacuum and controlled heat to it. The boiling point of the glycol could not be reached until most of the water it contained had been boiled away. Vapor from the boiling glycol was condensed, as it passed successively through vapor-to-glycol and vapor-to-air heat exchangers, and was deposited in the accumulators.

The reclaimer was skid-mounted and required only a natural gas fuel supply to be put in operation.

● The main reclaiming operation was carried out in the field. A total of 7250 gal of fouled glycol was processed. Of this amount, 6115 gal were reclaimed initially and returned to the dehydration plant. During the first run, 660 gal of salty sludge was drained from the reclaimer boiler, at clean-out times, and 475 gal of shrinkage was experienced. Of the latter, a large part is estimated to have been water initially contained in the glycol and lost as vapor through the vacuum pump discharge.

The 660 gal of drained-off sludge was then run through the reclaimer and 475 gal of usable glycol was recovered and returned to the plant. Final totals were 6590 gal of glycol reclaimed and 660 gal of shrinkage in water, contaminants and other losses. An overall recovery of 91 per cent was achieved.

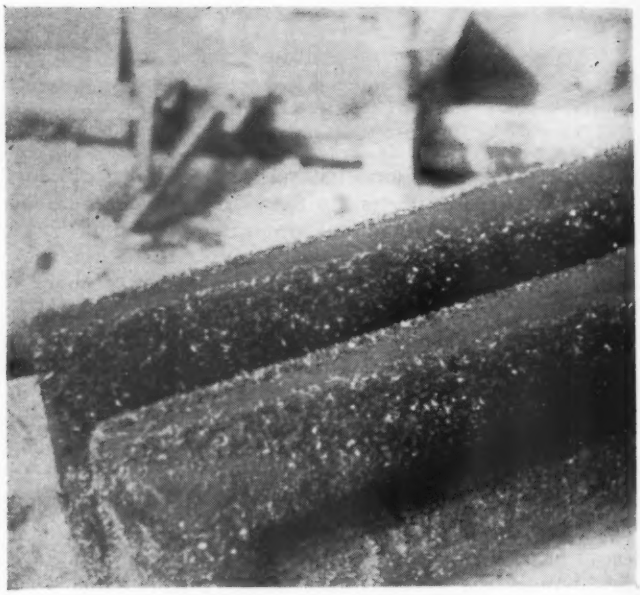
● Through the courtesy of Carbide and Carbon Chemicals Company, samples of reclaimed glycol were analyzed by the Mellon Institute of Industrial Research. Its reports indicated that the reclamation process has removed all objectionable amounts of salt, suspended matter, and heavy hydrocarbons originally present in the fouled glycol. The principal difference between reclaimed and new glycol, for dehydration purposes, was a decrease in pH value. The slight acidity of the reclaimed glycol was rendered relatively harmless by the addition of a corrosion inhibitor.

This particular experience has proved glycol reclamation to be an economical operation.

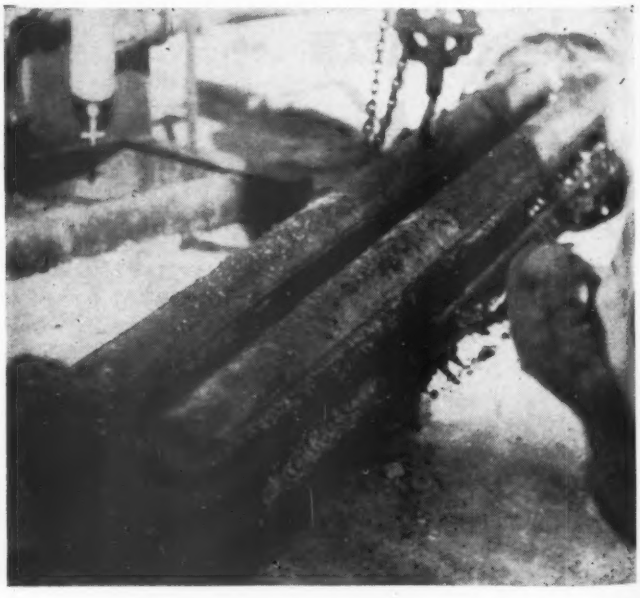
Operational checks of the rate of contamination determine the frequency of reclaiming, which is on an annual basis at present.

Acknowledgment. The author expresses appreciation to Gene Mitchell (photographs) and Charles B. Valliant (designer and operator of the reclaimer), both engineers with Black, Sivalls and Bryson, Inc., for their assistance in preparing this article.

Typical deposit of salty sludge in boiler of reclaimer



Deposits form on the reclaimer fire tubes making it necessary to remove and clean them. Twelve such cleanups were necessary. Above, photo shows salt deposits on tubes, photo below shows sludge deposits



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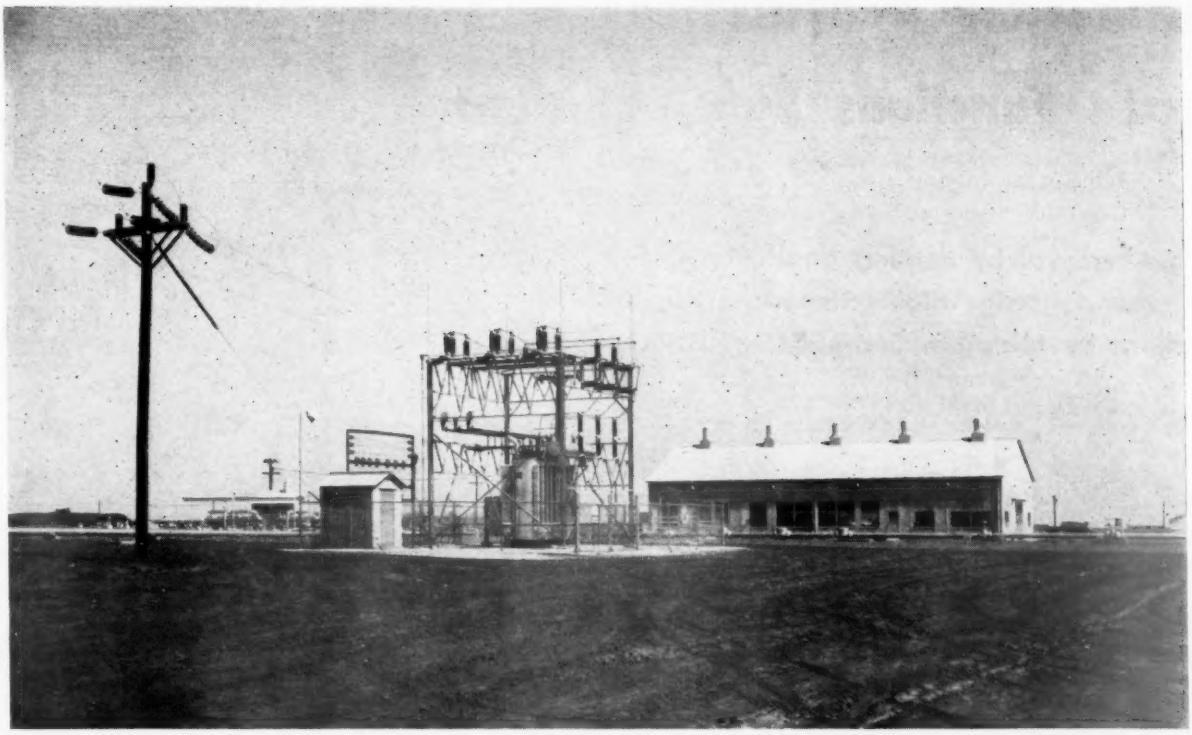

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Instrumentation Makes Austin Field Dehydration Plant's Functions Safe, Efficient

Hydrate removal by heating gas taken from underground storage highly important in winter operations by Michigan Consolidated Gas Company

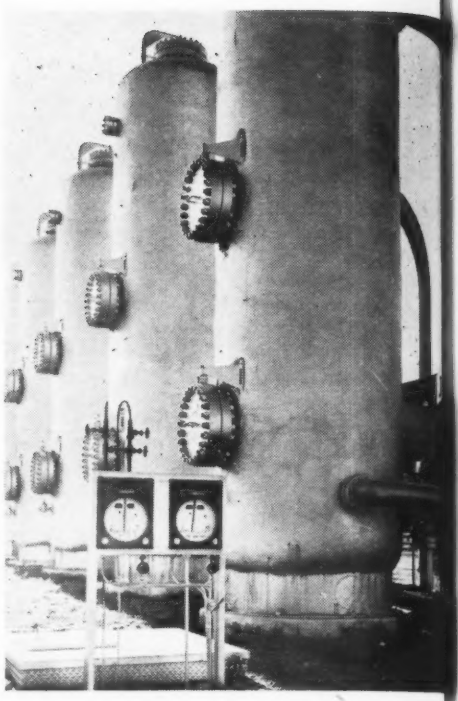


FIG. 1. Dehydrators showing wet gas inlet risers. Instruments in foreground are pneumatic pressure (PIT-2) and flow (FIT-2) transmitters on a cool regeneration gas inlet line.

ONE great problem of gas transmission and sales companies is the seasonal variation in demand for natural gas. Customer demand in the summer time is far below the volume needed for space heating requirements on a cold winter day. Long distance pipe lines can not be built to furnish gas only for the winter months. Line companies must sell the full pipe line capacity or nearly so every day of the year to be economically solvent.

EXCLUSIVE

To solve this problem, more and more companies are turning to underground storage. The Austin storage field of Michigan Consolidated Gas Company is one of several partially depleted gas fields in West Central Michigan which have been converted to underground storage use. Michigan-Wisconsin Pipe Line Company, an affiliate of Michigan Consolidated Gas

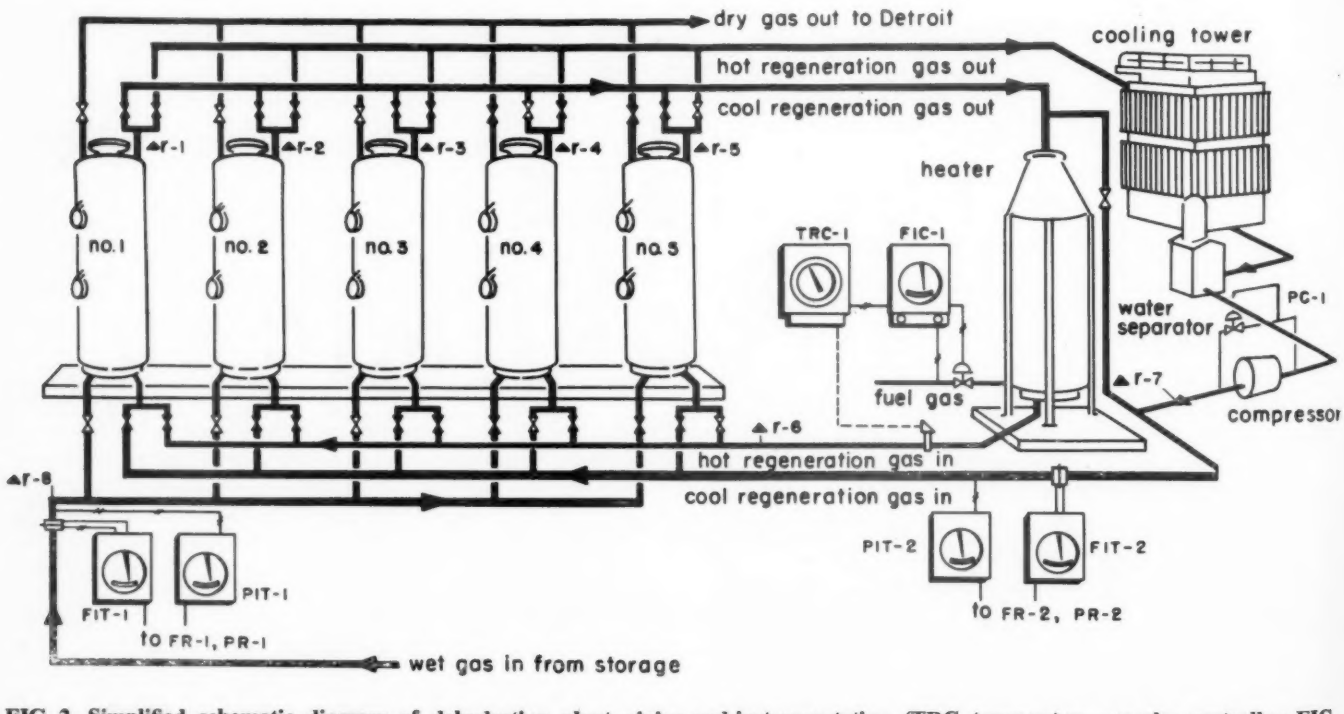


FIG. 2. Simplified schematic diagram of dehydration plant piping and instrumentation. (TRC, temperature recorder controller; FIC, indicating flow controller; PIT, indicating pressure transmitter; FIT, indicating flow transmitter; T/C, point of temperature measurement; PC, self-actuated pressure controller).

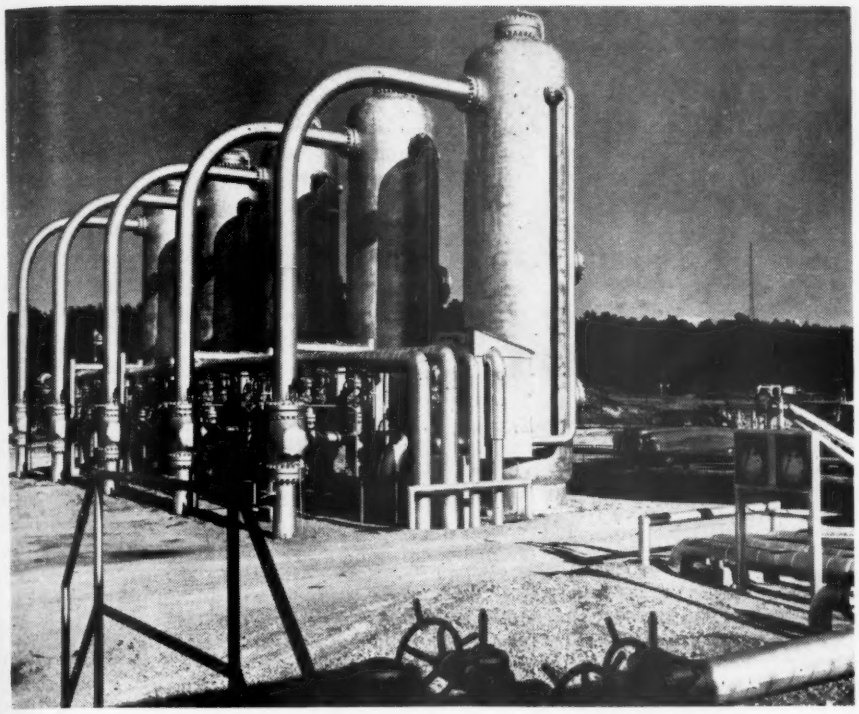


FIG. 3. Pneumatic flow and pressure transmitters for wet gas inlet header.

Company, pumps gas from Texas to Michigan and Wisconsin at an almost constant daily rate every day of the year.

Dehydration Control Critical

Instrumentation of the dehydration plant at Austin is a prime example of the proper use of instruments and valves for efficient, automatic operation of a continuous process that uses essentially batch processing vessels. Above and beyond providing continuity in switching dehydrators from regeneration cycles to on-stream cycles, the instruments make the plant one of extreme safety.

Flame failure and excess temperature cut-off devices[1] are used on the regeneration gas heater. Rupture discs are mounted on each dehydrator, and relief valves are placed on the water separator and across the regeneration gas compressor. A check valve on the outlet line from the heater prevents reverse flow when the inlet line is closed by the flame failure device. These are just a few examples of the instrumentation engineering that has gone into this plant to make it safe.

[1]Honeywell.

Hydrates 1300 Ft Down

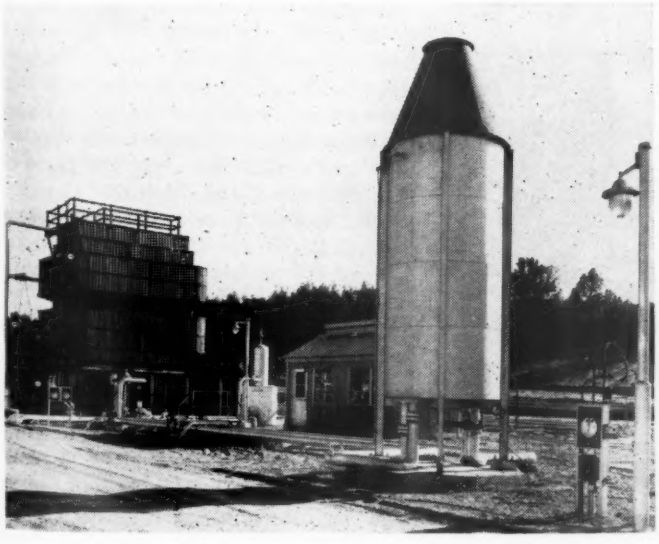
At present, four storage fields are utilized by this system and are located in the vicinity of Big Rapids, Michigan. The underground reservoirs are at a depth of approximately 1300 ft. The reservoir itself consists of microscopic pores in sandstone that are sufficiently numerous and connected to one another to allow large volumes of gas to be injected, stored, and withdrawn from the reservoir through wells drilled from the surface. The small pores in the sandstone by nature contain water, and the entire sandstone reservoir is underlaid with a sandstone whose pores are completely filled with water.

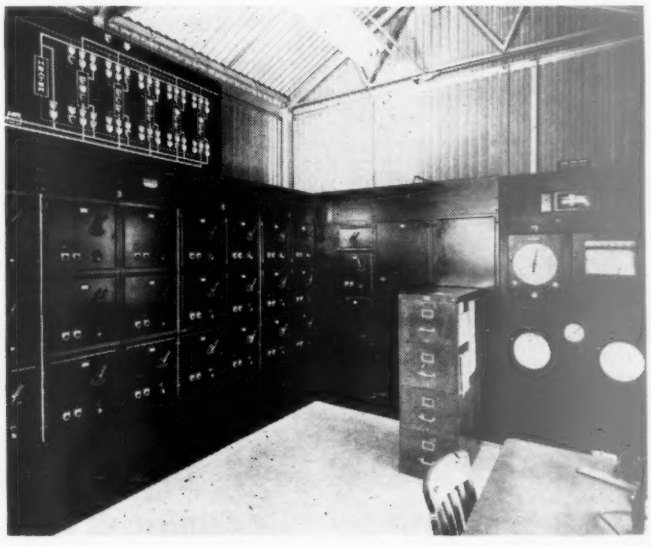
When gas was produced from the reservoir prior to its use as a storage area, such gas came to the surface saturated with water vapor. It is a phenomenon of natural gas that when subjected to high pressure in the presence of water, ice-like solids, called hydrates, may form at temperatures well above 32 deg, the freezing temperature of water. The formation of hydrates in gas transmission lines may reduce or completely stop gas flow.

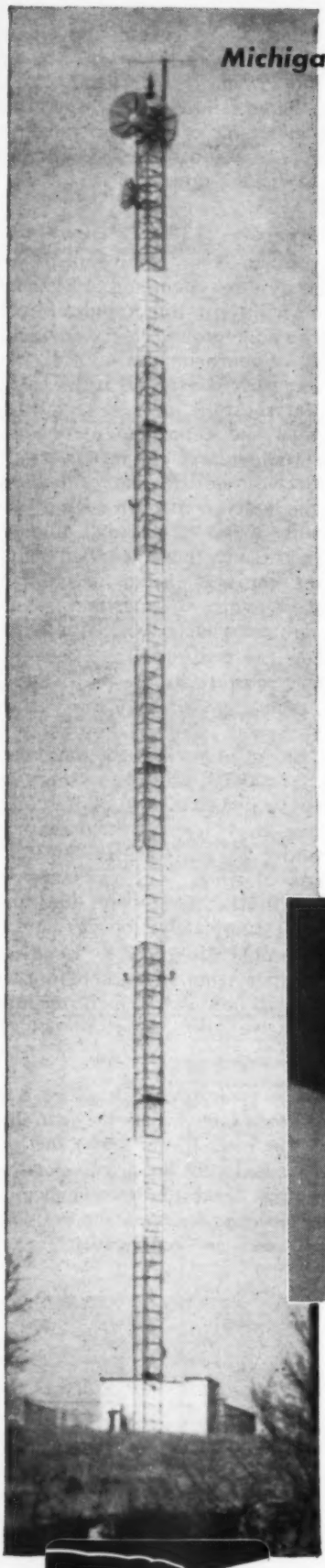
This problem is solved by removing water vapor from the gas before attempting to flow gas at high pressure. Accordingly, prior to pumping gas

FIG. 4. Left, cooling tower, water separator, compressor house, and regeration gas heater. Large instrument at right is the indicating flow controller on the fuel gas line to the heater. Two instruments at left are the indicating flow and pressure transmitters.

FIG. 5. Right, central control room housing timing system that switches dehydrators and miscellaneous recording instruments. Top instrument on control board is excess temperature controller. At left in center row is the controller which resets index of flow controller of heater fuel gas line. Strip chart recorder logs eight key temperatures in system. The two instruments flanking instrument air pressure gage are two pen recorders for flows and pressures in wet gas inlet header and cool regeneration gas inlet line.







Michigan-Wisconsin Pipeline Company

Assures power for repeater stations with ONAN Standby Electric Plants

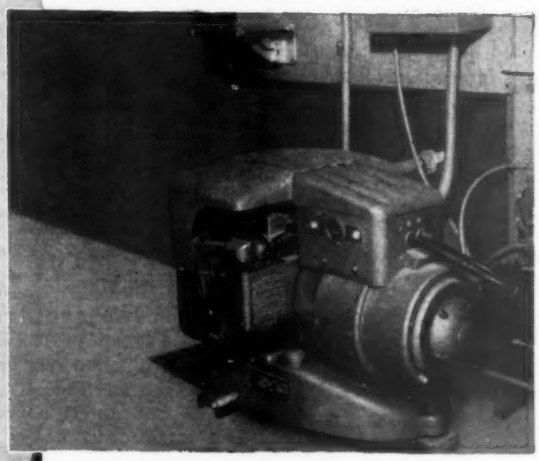
Microwave radio handles communications for the Michigan-Wisconsin pipeline which carries natural gas from Texas fields throughout Wisconsin and Michigan.

Of the 60 repeater stations in the system, 53 are unattended and are equipped with Onan Standby Electric Plants and Onan Automatic Line Transfer Controls. When commercial power is interrupted, the Onan plants start automatically and supply power for operating microwave equipment.

Most of the Onan units are Model 305CK electric plants of 3,500-watt capacity. This model, together with the Onan 5 and 10KW "CW" electric plants have built-in advantages for microwave standby service. They are air-cooled, extremely compact, and dependable.

If you have a problem in standby power, write our sales engineers. Onan builds electric plants for every need . . . from 400 to 55,000 watts.

Onan Model 305CK shown installed in the repeater station at Waukesha, Wisconsin. Bottled gas is used for fuel.



NEW AUTOMATIC MICROWAVE LINE TRANSFER CONTROL

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from Texas, water vapor is removed and gas reaches the storage fields free from water vapor.

Upon injection and storage of the gas in the underground field, the gas again picks up water from the reservoir, and removal of the water vapor is necessary before the gas can be transmitted to market. This is accomplished by the use of dehydrators located at the storage fields. These dehydration stations must be foolproof in their operation—and never fail, for a stoppage of gas flow on a cold winter day would be disastrous to the people of Detroit, and other customers of Michigan Consolidated depending on gas from storage to heat their homes.

Dehydration is done in the 5 packed vessels, illustrated, each about 20 ft high and 5½ ft in diameter. Gas is passed through these vessels, then to a compressor station, and then on to Detroit. As the packing in the dehydrator becomes saturated, the vessel is taken off the line, and dried out. Generally, there are three vessels on the line, and two on the drying cycle, with all action controlled automatically on a time basis. Engineering for the dehydration plant was done by Ford, Bacon, and Davis, Inc.

Five Dehydrators Used

The schematic piping diagram indicates the over-all operation of the dehydration plant. With this arrangement, dehydrators 1, 2, and 3 are on the on-stream gas drying cycle, while 4 and 5 are on the regeneration cycle.

Dehydrator No. 4 is passing cool regeneration gas, while No. 5 is being dried out with hot regeneration gas. After a set time interval, No. 4 will go on stream, No. 5 will switch to pass cool regeneration gas, and one of the first three dehydrators, will start to pass hot regeneration gas.

Each dehydrator is identical—the size, appearance, construction, and instrumentation of each are the same. Wet gas inlet risers extend from the buried wet gas header to a point near the tops of the dehydrators. Pressure gages, placed on the dehydrator side of the automatic inlet valves, are mounted low enough to be seen easily by outside personnel. A rotameter placed on the header side of the inlet valve provides a visual check on wet gas flow. Dried gas is returned directly to the buried dry gas header through the automatic outlet valve.

Thermocouples mounted in the regenerator gas outlets lead to an eight-record strip chart potentiometer,[2] where temperatures of hot and cold regeneration gases from the dehydrators are automatically charted. A blow-off line and hand valve, in addition to the rupture disc mentioned earlier,

completes the control picture of the dehydrators.

270 Deg of Cooling

The cooling tower is a Fluor Bentube* design. Temperature differential across the tower is approximately 270 deg, the hot gas at about 350 F being cooled to 70 or 80 F. A hand valve is provided on one of the spray headers for winter by-pass. Thermometers, not shown in the schematic drawing, measure inlet and outlet temperatures of hot regeneration gas.

The water separator is equipped with a level gage glass, relief valve, and blow down or drain traps and valving.

Cascade Control Needed

The furnace used to heat the regeneration gas is a vertical heater with a capacity of 3,100,000 Btu per hr. As mentioned earlier, both excess gas temperature and flame failure protection devices are employed. Either of these will shut off the flow of regeneration gas to the heater as well as the fuel gas, and will sound an alarm in the control room.

The thermocouple of a temperatture controller[3] is mounted in the hot gas outlet line. This circular chart controller is used in a cascade type arrangement to set the control index of a indicating flow controller[4] in the fuel gas line. The valve actuated by this flow controller is mounted in the fuel line just ahead of the solenoid valve that shuts off fuel gas in case of flame failure or excess flue gas temperature. A fuel gas regulator and by-pass is used to maintain proper fuel gas temperature.

Temperature of the wet gas in from the storage field is recorded on a strip chart recorder.[3] Also mounted in the wet gas inlet line are the orifice plate and pressure tap leading to a indicating flow transmitter[4] and an indicating pressure transmitter. These two instruments, mounted side by side near the main inlet, transmit to a two-pen recorder (FR-1, PR-1) mounted in the control room. A similar set of flow (FIT-2) and pressure (PIT-2) transmitters is connected into the cool regeneration gas line from the compressor to the cool inlet header. These instruments also transmit to a two-pen recorder (FR-2, PR-2) in the control room.

No effort has been spared to make the Austin field dehydration plant one of the most efficient and safe-operating plants in existence. Cool dry gas is supplied to the main compresors all year round, in the quantities needed, with no interruptions.

[2]Brown-ElectroniK.
*Trade Mark, Fluor Corporation.
[3]ElectroniK.
[4]Brown.

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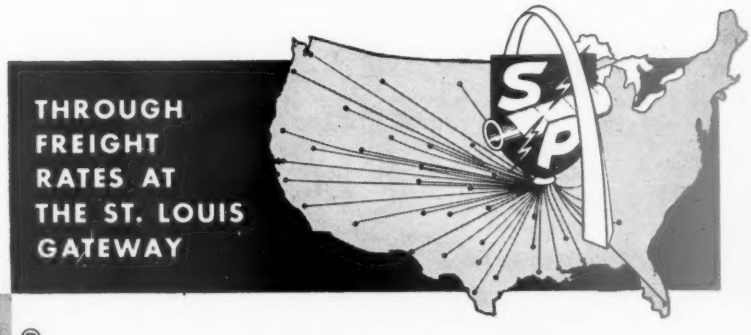

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For Your Pipeliners' Notebook

Viscosity and Fluid Friction Calculation Fundamentals

Tired of looking through handbooks and reference manuals for information? Here's a concise guide to viscosity and fluid friction theory, symbols, and calculations

Carl W. Boegehold

The following symbols and equations are used in this article discussing viscosity and describing methods of calculating the friction of flow and fluid in pipes.

Symbols

- h = Total frictional loss in feet head of the fluid
- H = Feet head loss per 100 ft of pipe
- P = Pressure loss in lb per sq in. per 100 ft of pipe
- L = Length of pipe in feet
- D = Average internal diameter of pipe in feet
- d = Average internal diameter of pipe in inches
- V = Average velocity in pipe in ft per sec.
- g = Gravity constant = 32.2 ft per sec^2
- f = Friction factor
- u = Absolute viscosity in centipoises
- γ = Kinematic viscosity in centistokes
- SUS = Kinematic viscosity in Saybolt Universal Seconds
- ρ = Density, mass per unit volume
- s = Specific gravity
- R = Reynolds Number
- r = Hydraulic radius

Equations

1. $h = f \frac{L}{D} \frac{V^2}{2g}$
1a. $h = f \frac{12L}{d} \frac{V^2}{2g}$
2. $V = \frac{GPM}{2.45\ d^2}$
3. $R = \frac{V_1 D_1 \rho}{u_1}$ See page D-64
4. $R = \frac{Vds}{u} \times 7740$
5. $\gamma = \frac{u}{s}$
6. $\gamma = \frac{SUS}{4.62}$ for SUS above 300. See Table 1 for SUS 300 and below
7. $f = \frac{64}{R}$ Laminar flow below Reynolds Number 1400
8. $H = \frac{.1543\ Vu}{d^2 s}$ Laminar flow
9. $H = \frac{18.67\ f\ V^2}{d}$ Turbulent flow
10. $P = \frac{.0668\ Vu}{d^2}$ Laminar flow
11. $P = \frac{8.08\ f\ V^2 s}{d}$ Turbulent flow
12. $r = \frac{\text{Cross sectional area}}{\text{Wetted perimeter}} = \frac{d}{4}$ for circular cross section
13. $\gamma = 92900 \times$ English kinematic viscosity)

THE VISCOSITY OF A FLUID, LIQUID, OR gas is that property that tends to resist relative motion of its particles. The unit of viscosity is defined as follows. *Assume two parallel plates of equal area unit distance apart and the space between filled with fluid. A force is applied to move the upper plate at unit velocity parallel to the lower fixed plate. When the force is unit force per unit area, the fluid has unit viscosity.*

When the distance apart is 1 cm, the velocity 1 cm per second and the force 1 dyne per sq cm, the viscosity is 1 poise.

Similarly, when the units are 1 ft, 1 ft per sec. and 1 lb per sq ft, the viscosity is 1 English unit. No name has been given this unit.

There are two other possible units. One is metric, using 1 gram force, and the other English, using 1 poundal force, but these are rarely used.

The flow condition used in defining the unit of viscosity is similar to that in a lubricated bearing or is approximately that occurring in a deep well centrifugal pump, where a shaft is rotating in oil in an enclosing tube.

The most common use of viscosity is in connection with the flow of liquids in circular pipes. For a tube 1 cm inside diameter, 1 cm long, velocity 1 cm per sec, and viscosity 1 poise, the friction loss is 32 dynes per sq cm.

The poise and English unit defined above are units of "absolute viscosity" and are a direct measure of the viscosity. Another unit is "kinematic viscosity"; this is simply the ratio of absolute viscosity divided by the mass

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TABLE 1. Viscosity conversion.

Saybolt Universal Seconds SUS	Kinematic Viscosity Centistokes	Saybolt Furol Seconds SFS	Redwood 1 (Standard) Seconds	Redwood 2 (Admiralty) Seconds	Degrees Engler	Degrees Barbey
31	1.00		29		1.00	5200
35	2.70		32		1.18	1925
40	4.30		35.8		1.31	1210
50	7.40		44.1		1.59	702
60	10.3		52.7		1.88	505
70	13.1		61.5		2.18	397
80	15.7		70.2		2.47	331
90	18.2		78.7		2.77	286
100	20.6		87.1		3.05	252
150	32.1		131.5		4.48	162
200	43.2		176		5.89	120
250	54.0	27.8	219		7.29	96.2
300	65.0	32.7	264		8.73	80.0
400	86.6	42.5	350		11.50	60.0
500	108	52.2	438	53.8	14.35	48.0
600	130	62.2	526	64.0	17.25	40.0
700	152	72.4	613	69.6	20.1	34.3
800	173	82.1	700	74.0	23.0	30.0
900	195	92.4	788	84.0	25.9	26.6
1000	217	102.6	876	88.7	28.7	24.0
1500	325	153	1310	126	43.1	16.0
2000	433	203	1750	165	57.5	12.0
2500	541	254	2190	204	71.8	9.6
3000	649	305	2630	243	86.2	8.0
4000	866	407	3500	323	115	6.0
5000	1082	509	4380	402	143.5	4.8
6000	1300	611	5260	483	172.5	4.0
7000	1515	712	6130	560	201	3.43
8000	1730	815	7000	640	230	3.00
9000	1950	916	7880	722	259	2.66
10000	2165	1020	8760	802	287	2.40
15000	3250	1525	13100	1203	431	1.60
20000	4330	2035	17500	1604	575	1.20

Above 300 SUS, centistokes $= \frac{\text{SUS}}{4.62}$

Above the range of this table
SUS = 9.83 SFS
= 1.142 Redwood #1 (Standard)
= 12 48 Redwood #2 (Admiralty)
= 34.8 Degrees Engler
$= \frac{24{,}000}{\text{Degrees Barbey}}$

Viscosity Relations for Table 1

SUS to centistokes based on ASTM D-446-39

Above 300 SUS, Centistokes $= \frac{\text{SUS}}{4.62}$

SFS centistokes based on ASTM D-666-44

Above 200 SFS, Centistokes $= \frac{\text{SFS}}{.47}$

Redwood #1 seconds
When $34 < t > 100$ Centistokes $= .260\,t - \frac{179}{t}$

When $t > 100$ Centistokes $= .247\,t - \frac{50}{t}$

Redwood #2 seconds (Admiralty) Centistokes $= 2.7\,t - \frac{2000}{t}$

Engler seconds Centistokes $= .147\,t - \frac{374}{t}$

$\text{Degrees} = \frac{t}{51.3}$

Barbey degrees Centistokes $= \frac{5200}{\text{Barbey deg.}}$

Redwood & Engler equations from *Marks Handbook* Page 231 Fifth Edition.
Barbey equation from Texas Company "Lubrication" May 1950, Page 56.

per unit volume $\frac{u_1}{\rho}$. Its reciprocal appears in equation 3 for the Reynolds Number. When u_1 is in poises and ρ is in grams per cu cm, $\frac{u_1}{\rho} = \frac{u_1}{s}$ and the kinematic viscosity is in stokes. When u_1 is in English units and ρ is in $\frac{\text{lb per cu ft}}{32.2}$, $\frac{u_1}{\rho} = \frac{u_1}{1.94s}$ and the kinematic viscosity is in English units.

The metric units are generally preferred. The poise and stoke are somewhat large and units $\frac{1}{100}$ as large called the centipoise and centistoke are used for liquids of low viscosity. The English units are too large, one kinematic English unit is 92,900 times as large as one centistoke. Water at 68.4 F has a kinematic viscosity of 1 centistoke or of .00001076 in English units. Using the English unit is about as awkward as using .0000158 miles instead of 1 inch on a drawing.

The viscosity in Saybolt Universal Seconds (SUS) is a measure of kinematic viscosity. The relation of this and other units to centistokes is given by equation 6 and Table 1.

In considering the relation between different units of measurement, it should be noted that there are two ways of stating the relation.

Case 1. The relative size of the units as 1 foot = 12 inches.

Case 2. The relative number of units in a given quantity as inches = 12 × feet.

This distinction usually causes no trouble with familiar units, but can easily cause confusion when comparing unfamiliar units such as the metric and English units of viscosity.

The above statements about the size of English units and the viscosity of water are Case 1.

If we stated "viscosity in English units = .00001076 centipoises," we would have Case 2. The equations listed separately are Case 2.

Dimensional analysis expresses relations in terms of the basic dimensions where:

L = Length

T = Time

M = Mass

An alternate system uses F = Force instead of M = Mass. The relation between the two is $F = \frac{ML}{T^2}$

Like the man who discovered he had been talking prose all his life, we find we have been using these dimensional relations right along. Thus velocity in ft per sec is $\frac{L}{T}$, acceleration in ft per sec^2 is $\frac{L}{T^2}$, volume is L^3, etc.

The units of viscosity can be similarly expressed, derived from the definitions. Thus absolute viscosity is $\frac{FT}{L^2}$ in the force system and $\frac{M}{LT}$ in the mass system. Kinematic viscosity is $\frac{L^2}{T}$ in either system.

Where no specific name has been given a viscosity, as for the English units, the unit is described in dimensional terms. Thus English absolute viscosity is $\frac{\text{pounds force} \times \text{seconds}}{\text{sq ft}}$ or $\frac{\text{slugs mass}}{\text{feet} \times \text{seconds}}$. English kinematic viscosity is $\frac{\text{sq ft}}{\text{sec}}$

Poises are $\frac{\text{dynes} \times \text{seconds}}{\text{sq cm}}$ or $\frac{\text{grams mass}}{\text{cm sec}}$

Stokes are $\frac{\text{sq cm}}{\text{sec}}$

This will explain the units described on page 230 of *Marks' Handbook*, Fifth Edition or page 244 Fourth Edition.

Viscosity of a liquid is measured by several methods. The Saybolt *(U. S.)*, Redwood *(English)* and Engler *(German)* viscosimeters measure the time of flow of a specific quantity of the liquid through a small short tube with a gravity head. The Barbey Ixometer *(French)* has a long flow tube restricted by a steel rod along its axis. This instrument measures the flow rate per hour under a fixed gravity head. Since the specific gravity is involved, these instruments all measure kinematic viscosity.

TABLE 2. Friction factors
Turbulent flow
New steel pipe

Pipe size	½	¾	1	1¼	1½	2	2½	3	4	6	8	10	12
I. D.	.622	.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	6.065	7.981	10.02	11.938
Reynolds number in thousands							Factor						
1.4	.047	.046	.046	.046	.045	.045	.045	.045	.045	.045	.045	.045	.045
2	.047	.046	.046	.046	.045	.045	.045	.045	.045	.045	.045	.045	.045
3	.047	.046	.046	.046	.045	.045	.045	.045	.045	.045	.045	.045	.045
4	.044	.043	.042	.042	.042	.041	.041	.041	.041	.041	.041	.041	.041
5	.041	.041	.040	.040	.040	.039	.039	.039	.039	.038	.038	.039	.039
6	.040	.039	.038	.038	.037	.038	.037	.037	.037	.036	.036	.036	.036
8	.037	.037	.036	.036	.035	.035	.035	.034	.034	.034	.034	.034	.034
10	.036	.035	.034	.034	.033	.033	.033	.032	.032	.032	.032	.032	.032
15	.033	.033	.031	.031	.031	.030	.030	.029	.029	.029	.029	.029	.029
20	.032	.031	.030	.029	.029	.028	.028	.028	.028	.027	.027	.027	.027
30	.031	.029	.028	.028	.027	.026	.026	.026	.026	.025	.025	.025	.025
40	.030	.029	.027	.027	.026	.025	.025	.024	.024	.024	.023	.023	.023
50	.029	.028	.027	.026	.025	.024	.024	.023	.023	.023	.022	.022	.022
60	.029	.028	.026	.025	.025	.024	.023	.023	.022	.022	.022	.021	.021
80	.028	.027	.026	.025	.024	.023	.022	.022	.021	.021	.021	.020	.020
100	.028	.027	.025	.024	.023	.022	.022	.021	.021	.020	.020	.020	.019
150	.028	.026	.025	.023	.023	.022	.021	.020	.020	.019	.019	.018	.018
200	.028	.026	.024	.023	.022	.021	.020	.020	.019	.018	.018	.017	.017
300	.027	.025	.024	.023	.022	.021	.020	.019	.018	.018	.017	.017	.016
400	.027	.025	.024	.023	.022	.020	.020	.019	.018	.017	.017	.016	.016
500	.027	.025	.024	.022	.022	.020	.020	.019	.018	.017	.016	.016	.015
600	.027	.025	.024	.022	.022	.020	.019	.019	.018	.017	.016	.015	.015
800	.027	.025	.024	.022	.021	.020	.019	.018	.017	.016	.016	.015	.015
1000	.027	.025	.023	.022	.021	.020	.019	.018	.017	.016	.016	.015	.015
1500	.027	.025	.023	.022	.021	.020	.019	.018	.017	.016	.015	.015	.014
2000	.027	.025	.023	.022	.021	.020	.019	.018	.017	.016	.015	.015	.014
3000	.027	.025	.023	.022	.021	.020	.019	.018	.017	.016	.015	.014	.014
4000	.027	.025	.023	.022	.021	.020	.019	.018	.017	.016	.015	.014	.014
5000	.027	.025	.023	.022	.021	.020	.019	.018	.017	.016	.015	.014	.014

For a Reynolds Number of 6000, the following factors should be used: 6-in., .0155; 8-in., .0145; 10-in., .014; and 12-in., .0135.
Above factors based on curves in Friction Factors for Pipe Flow by Professor Lewis F. Moody in Transactions of the ASME November, 1944.

Another method is to spin a disc or cylinder in the liquid at a known speed and measure the torque. The Brookfield Viscometer is of this type and measures the absolute viscosity.

Fluid Friction

The basic equation is 1. or 1a. The friction factor f varies with a ratio consisting of velocity, diameter, weight per cubic unit, and absolute viscosity. This ratio is called the Reynolds Number as per equation 3. The Reynolds Number is sometimes called a dimensionless ratio.

This means that it has an inherent value that is independent of the system of dimensions used. Take the simple case of the ratio of length and width of a desk top 5 ft by 3 ft. The ratio is $\frac{5}{3}$ and remains the same whether measured in feet, inches, centimeters, or meters. Expressed in dimensional symbols we have $\frac{L}{L} = 1$, this indicates a dimensionless ratio.

Now express $R = \frac{V_1 D_1 \rho}{u_1}$ by the same method.

$$R = \frac{L}{T} \times L \times \frac{T}{L^2} = 1$$

Thus this ratio has the same value for any system of measurement, provided the several quantities are expressed in consistent units.

For the metric system, this would mean velocity (V_1) in cm per sec, diameter (D_1) in cm, density (ρ) in grams per cu cm, and viscosity (u_1) in poises, a unit based on the dyne and cm. Similarly for the English system this would mean velocity (V_1) in ft per sec, diameter (D_1) in feet, density (ρ) in slugs

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TABLE 3. Friction factors
Turbulent flow
New steel pipe

Pipe size I. D.	14 13.5	16 15.375	18 17.375	20 19.375	22 21.375	24 23.375	26 25.375 25.25	30 29.375 29.25	34 33.375 33.25	36 35.375 35.25
Reynolds number in thousands				Factorf						
1.4	.044	.044	.044	.044	.044	.044	.044	.044	.044	.044
2	.044	.044	.044	.044	.044	.044	.044	.044	.044	.044
3	.044	.044	.044	.044	.044	.044	.044	.044	.044	.044
4	.041	.041	.041	.041	.041	.041	.041	.041	.041	.041
5	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039
6	.036	.036	.036	.036	.036	.036	.036	.036	.036	.036
8	.034	.034	.034	.034	.034	.034	.034	.034	.034	.034
10	.032	.032	.032	.032	.032	.032	.032	.032	.032	.032
15	.029	.029	.029	.029	.029	.029	.029	.029	.029	.029
20	.027	.027	.027	.027	.027	.027	.027	.027	.027	.027
30	.025	.025	.025	.025	.025	.025	.025	.025	.025	.025
40	.023	.023	.023	.023	.023	.023	.023	.023	.023	.023
50	.022	.022	.022	.022	.022	.022	.022	.022	.022	.022
60	.021	.021	.021	.021	.021	.021	.021	.021	.021	.021
80	.020	.020	.020	.020	.020	.020	.020	.020	.020	.020
100	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019
150	.018	.018	.018	.018	.018	.018	.018	.018	.018	.018
200	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017
300	.016	.016	.016	.016	.016	.016	.0155	.0155	.0155	.0155
400	.016	.016	.0155	.015	.015	.015	.015	.015	.015	.015
500	.015	.015	.015	.015	.0145	.0145	.0145	.0145	.0145	.0145
600	.015	.015	.0145	.0145	.0145	.014	.014	.014	.014	.014
800	.015	.0145	.014	.014	.014	.014	.0135	.0135	.0135	.0135
1000	.0145	.014	.014	.0135	.0135	.0135	.0135	.013	.013	.013
1500	.014	.0135	.0135	.013	.013	.013	.013	.0125	.0125	.0.25
2000	.0135	.0135	.013	.013	.013	.0125	.0125	.0125	.012	.012
3000	.0135	.013	.013	.013	.0125	.0125	.0125	.012	.012	.012
4000	.0135	.013	.013	.0125	.0125	.012	.012	.012	.0115	.0115
5000	.013	.013	.0125	.0125	.0125	.012	.012	.0115	.0115	.0115
6000	.013	.013	.0125	.0125	.012	.012	.0115	.0115	.0115	.0115
8000	.013	.013	.0125	.0125	.012	.012	.012	.0115	.011	.011
10000	.013	.0125	.0125	.012	.012	.012	.0115	.0115	.011	.011
15000						.012	.0115	.0115	.011	.011
20000						.0115	.0115	.0115	.011	.011

For higher Reynolds Numbers, f remains constant at the lowest tabular value.

(32.2 lb) per cu ft and viscosity (u_1) in English units based on the pound force and feet.

We generally use velocity in ft per sec, diameter in inches, and viscosity in centipoises. In the metric system $\rho = s$ and to take care of the mixture of units a factor must be introduced so that we have equation 4 to calculate the Reynolds Number.

Note that in equation 4 there appears the reciprocal of $\frac{u}{s}$. This ratio is the kinematic viscosity in centistokes as expressed by equation 5.

There are two types of flow, usually called laminar and turbulent. In laminar flow the liquid moves as if it were an assembly of thin concentric tubes with no cross flow, and velocities increase toward the center of the pipe. The average velocity is one-half the maximum velocity at the center. In turbulent flow, there is an eddying, mixing type of motion and the average velocity is 80 per cent of that at the center.

Laminar flow exists at Reynolds Numbers 2000 and below; turbulent flow at 4000 and above. In laminar flow, the friction factor has a simple relation to the Reynolds Number as per equation 7.

The friction factor decreases from .064 at Reynolds Number 1000 to .032 at 2000 and then jumps up to about .045 at 3000. The region between 2000 and 4000 is a critical zone where the friction factor is indeterminate and may pulsate depending on flow conditions. Therefore, for estimating purposes, Table 2 shows friction factors that are on the high side for Reynolds Numbers 1400 to 4000. In this way a decrease in viscosity through the critical zone with consequent increase in Reynolds Number will not cause an increase in

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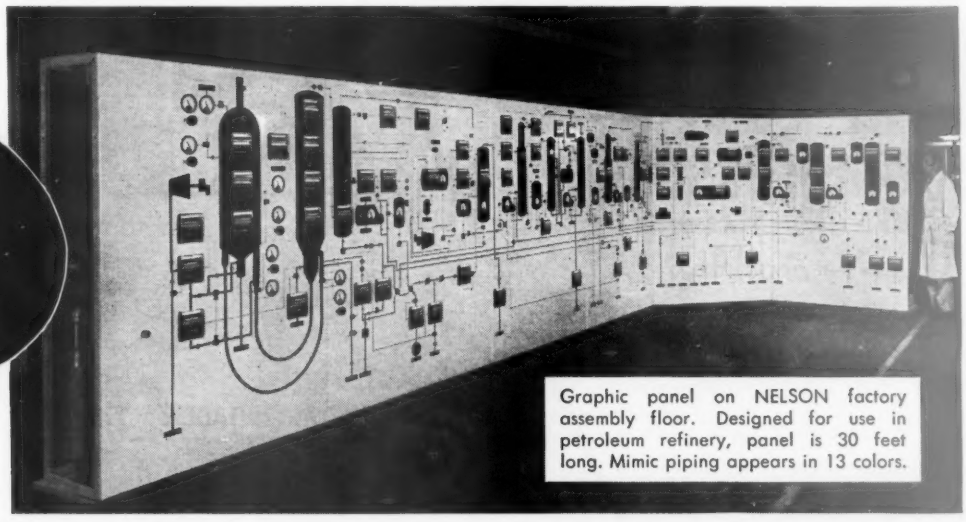

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friction above that estimated.

In turbulent flow there is also a definite relation between friction factor and Reynolds Number, but not so simple as in laminar flow. For very smooth pipe, there is a single value of f for every value of R, regardless of pipe diameter.

The roughness of ordinary pipe, however, has an increasing influence as the pipe size decreases. Therefore, for any value of R there is a different f for each size pipe. The relation between R and f in turbulent flow must be expressed by a series of curves or a tabulation as per Table 2. Note that as R increases, f decreases more slowly until at high values of R, f becomes constant.

Now for laminar flow take equation 1a where:

$$h = f\frac{12L}{d}\frac{V^2}{2g}$$

and substitute

$$L = 100 \text{ and } f = \frac{64}{R} = \frac{64u}{Vds \times 7740}$$

and we obtain equation 8.

R must be calculated to determine if the flow is laminar but f need not be directly calculated to determine the friction for laminar flow.

For turbulent flow, start again with equation 1a as above and substitute: $L = 100$ and we obtain equation 9. Now in equation 8 and 9 substitute $H = \frac{P \times 2.31}{s}$ and we obtain equations 10 and 11.

The friction factors are based on the average results of many tests. Individual cases may be 5 to 10 per cent higher; therefore, in estimating, add 10 per cent to the calculated figures. For old pipe, a further safety factor should be added.

Equation 1a applies to pipes with circular cross section. A more general form for non-circular cross sections can be based on the hydraulic radius (r) which is defined by equation 12. For a circular pipe, $d = 4r$, so that 4r substituted for d in equations 8 to 11 provides a means for calculating friction loss for special shapes of conduits.

In laminar flow this holds only for shapes that do not vary too widely from the circular. For rectangular or annular shapes the friction may be as much as 50 per cent more than for circular shapes of the same hydraulic radius.

Examples

Given 200 gpm oil at s = .80, 4-in. pipe, viscosity (a) 400 centipoises and (b) 25 centipoises. What is head and pressure loss per 100 ft of pipe?

(a) $$V = \frac{200}{2.45 \times 4.026^2} = 5.04$$ . . . . . Eq. 2

$$R = \frac{5.04 \times 4.026 \times .80 \times 7740}{400} = 315$$ . . . . . Eq. 4

$$H = \frac{.1543 \times 5.04 \times 400}{4.026^2 \times .80} = 24 \text{ ft} \quad . \ . \ . \quad \text{Eq. 8}$$

$$P = \frac{.0668 \times 5.04 \times 400}{4.026^2} = 8.3 \text{ lb} \quad . \ . \ . \quad \text{Eq. 10}$$

Adding 10 per cent, H = 26.4 ft and P = 9.2 lb

(b) $$R = \frac{5.04 \times 4.026 \times .80 \times 7740}{25} = 5050$$ . . . . . Eq. 4

f = .039 . . . . Table 1

$$H = \frac{18.67 \times .039 \times 5.04^2}{4.026} = 4.6 \text{ ft} \quad . \ . \ . \quad \text{Eq. 9}$$

$$P = \frac{8.08 \times .039 \times 5.04^2 \times .80}{4.026} = 1.59 \text{ lb} \quad . \ . \ . \quad \text{Eq. 11}$$

Adding 10 per cent, H = 5.1 ft and P = 1.75 lb

Using the above data, there can be constructed a chart of curves for each size pipe so that the type of flow can be determined and the friction loss per 100 ft can be read directly. This has been done by the Hydraulic Institute and published in a pamphlet entitled "Pipe Friction." ★ ★ ★

The Author

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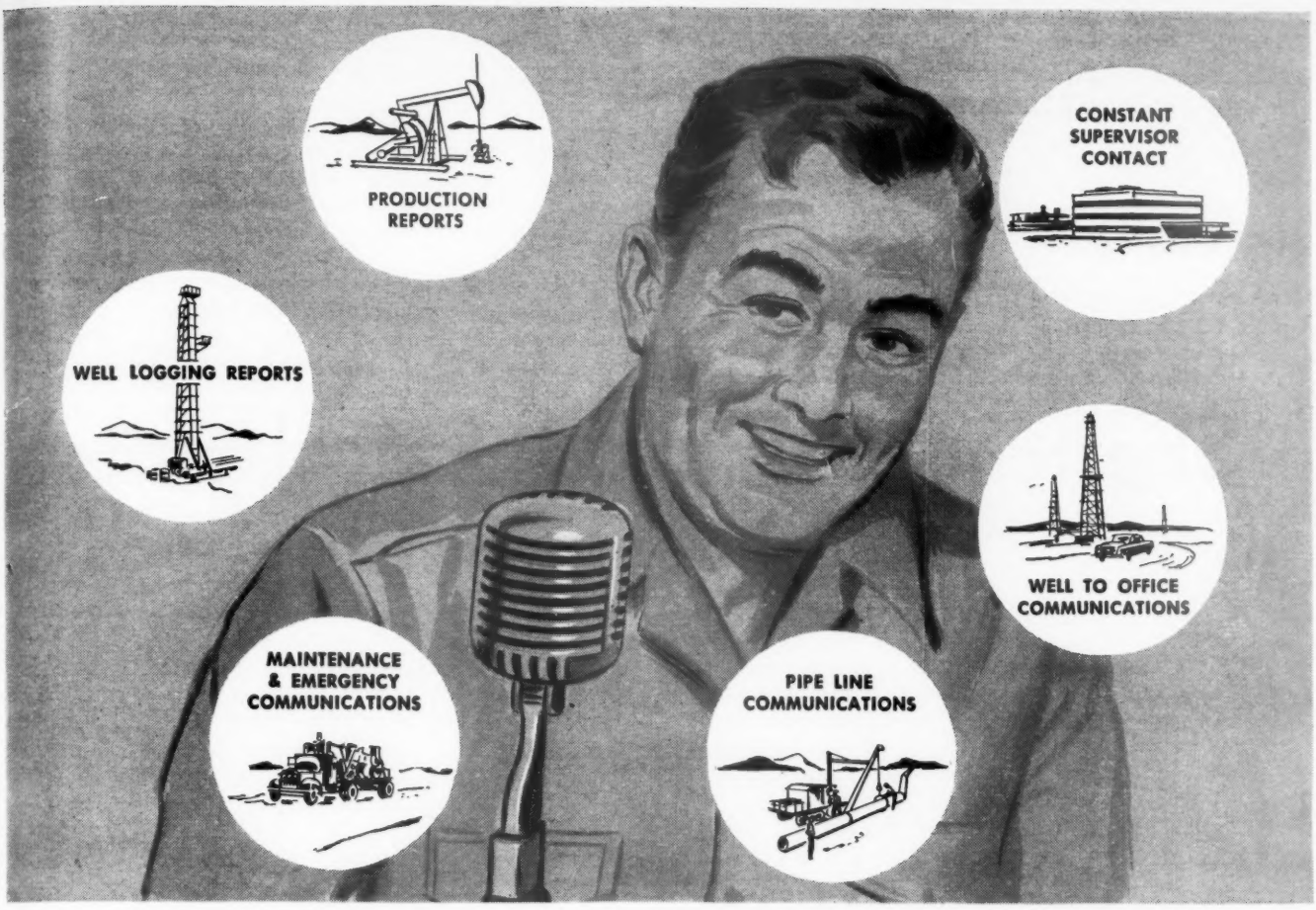

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Doing "out-of-the-office" engineering?

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Shortcuts for Field Calculations

J. W. J. Bercher*

THE FIELD ENGINEER IS OFTEN FACED WITH THE NECESSITY of reaching a figure in the field that will be accurate enough for use at the moment, even though it may not be exact. In the office, with a group of handbooks, with calculating machines, with the curves he may have accumulated over the years, these estimates are usually simple.

In the field, however, he must rely almost entirely upon the information which he can carry in his pocket, or, better, in his head. In this discussion, suggestions will be made that have been found of value, and it is hoped that they will, in turn, lead the ingenuity of the reader to develop others.

Realizing that he will have occasion to make these field estimates, the engineer should, while in the office, prepare for them. This is not difficult, and the effort will be well worth the time and trouble required. A typical problem, which the gas pipeliner must often meet, is that of the amount of gas in a section of line. The formula generally used in this determination is

$$V = \tfrac{1}{4} \times \pi \times \left(\frac{d}{12}\right)^2 \times l \times \left(\frac{P_1}{P_b}\right) l$$

where

V = volume, cubic feet
d = inside diameter of pipe line, inches
l = length of pipe line in feet
P_1 = pressure in the pipe line, psia
P_b = pressure base in use, psia

This formula offers no difficulty in the office, but if used in the field, during a heavy rain, it offers somewhat more difficulty. It is suggested that during a day in the office, the formula may be adapted to field use in the following manner. Since certain of the terms have definite numerical values, and since others have values which are fixed by agreement, we may group these terms into a single value for convenience.

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First we will group

$$\tfrac{1}{4} \times 3.1416 \times \tfrac{1}{144} \times \tfrac{1}{14.7} = 0.000371031$$

If we put this value into the formula, we will now have

$$V = 0.000371031 \times d^2 \times l \times P$$

But we will seldom if ever, have occasion to want the volume of gas in a single foot of line, so we will write the formula for a unit of length better suited to our need in the field, say a length of 1000 ft, giving

$$V = 0.371031 \times d^2 \times l \times P$$

Where

V = cubic feet
l = length of the pipe line, in thousands of feet

The most common unit of length is the mile, so we may write

$$V = 1.95904 \times d^2 \times P \times l$$

where

V = cubic feet
l = length of the pipe line, in miles

An examination of the factors indicates that we will not be in serious error if we round off the values, writing 0.4 for 0.371, and 2.0 for 1.959.

We now have for the volume of gas in one mile of pipe

$$V = 2 \times P \times d^2$$

In this, the value of d is the internal diameter of the pipe; but for the larger pipe sizes, there is no serious error in letting d be the nominal pipe size. Take the case of nominal 16-in., 0.5-in. wall, the nominal pipe size, or 16, squared is 256; the actual i.d. of 15 squared, is 225. The difference is 31, or an error of about 14 per cent.

In the case of 24-in. nominal, with the same wall, the error is about 9 per cent So, in the range of pipe sizes normally

used in transmission lines, the accuracy of the short cut can be either neglected, or rounded off at about 10 per cent. The other factors, such as temperature effects, fugacity, and the like will usually tend to reduce the actual error.

This same formula lends itself nicely to use in the situation, where a section of line must be shut in for repairs, and it is necessary to estimate the length of time service can be continued from the gas in storage in the line. In this case, the value of P to be used is the difference between the line pressure at the time of the shut-down, and the lowest safe pressure to which it may be reduced. Or, if the consumption from the line is known, the downtime can be estimated, and from the formula, it is possible to determine whether or not the pressure will be ample to serve the customers during the shut down.

WHERE THE LINE IS CARRYING OIL, OR SOME OTHER LIQUID, the effect of pressure is eliminated, and the formula assumes a slightly different form. The basic formula, for volume in cubic feet, is

$$V = \tfrac{1}{4} \times \pi \times \left(\frac{d}{12}\right)^2 \times l$$

where all values are the same as in the basic formula for gas.

The practice in handling liquids rarely calls for volume in cu ft, so it is necessary to convert this formula to the units desired. We will convert first to gallons, since this is the most common unit. Since one cu ft is equal to 7.480519 gal, if V is desired in gallons we will have

$$V = 7.480519 \times \tfrac{1}{4} \times \pi \left(\frac{d}{12}\right)^2 \times l, \text{ or}$$

$$V = 0.0407999 \times d \times l$$

For a unit length of 1000 ft, with the volume in gallons,

$$V = 40.7999 \times d \times l$$

This is a factor nearly equal to the number of gallons in one barrel of oil, so for a quick figure in barrels, we might use

$$V = d^2$$

where V is the number of barrels in 1000 ft of the line.

For a unit of length of one mile the factor will become for the case, where the capacity is wanted in gallons:

$$V = 5280 \times 7.480519 \times \tfrac{1}{4} \times \pi \times \left(\frac{d^2}{144}\right) \times l$$

$$V = 215.423 \times d^2 \times l$$

which, when rounded off gives a very convenient figure for field use.

IF ONE KEEPS IN MIND THE APPROXIMATE MAGNITUDE OF the errors in rounding off the factors, there is no reason for hesitancy in making use of such simplified methods. It might be well to remember, also, that any formula which may be used in finding the capacity of a pipe line, may also be used to find the capacity of a circular vertical tank.

In the calculations made above, π was taken equal to 3.1416. This is rarely justified in the field. Use of 3⅐ is normally just as the measurements can justify. The figure 3.1416 is exact to four decimal places, but how many field measurements, made with a tape, or a rule, are exact to one-ten-thousandths? The value 3⅐ may be used mentally, which is certainly a point in its favor.

The field engineer should miss no opportunity to make use of one of the short cuts and rules that make mental calculations possible. In squaring two, or more, digit numbers there is such a device, often overlooked.

Many engineers fail to apply the binominal theorem in such cases. This theorem which is written in two ways is

$$(a + b)^2 = a^2 + 2ab + b^2$$
$$(a - b)^2 = a^2 - 2ab + b^2$$

Either of these may be used, the choice depending upon the individual. Suppose that we wish to apply the formula for barrels of liquid to a tank 68 in. in diameter. To find the value of 68 squared, try this method

$$68 = 70 - 2$$
$$(70 - 2)^2 = 4900 - 280 + 4 = 4624$$

or it might be done

$$(60 + 8) = 3600 + 960 + 65 = 4624$$

With only a small amount of practice one soon bcomes adept, and much time is saved.

WHILE DISCUSSING SQUARES, IT MIGHT BE IN ORDER TO TOUCH upon the application of the laws of exponents. Here again many fail to make full use of the methods available. The principle operations using exponents are outlined below:

$$A^n \times A^m = A^{n+m}$$
$$A^n \div A^m = A^{n-m}$$
$$(A^n)^m = A^{mn}$$

In the above, A is any number, and n and m are any exponents. To further clarify what is to follow, consider that if

$$x + y = n$$

then it must be true that $A^n = A^{x+y}$.

This use of the laws of exponents is often overlooked. It is often necessary to find such powers of numbers as the ⅝ in solving flow formulae, and it is surprising how often the calculator fails to take advantage of the fact that ⅝ is equal to 2 + ½, and to 3 — ½.

In other words, the square of the number times the square root of the number is equal to the number to the ⅝ power, or if preferred, the cube of the number divided by the square root of the number is equal to the ⅝ power of the number. Just a little time spent in deciding the relations which exist may save much time in performing the required calculation.

Also of real practical value, if properly applied, is the fact that

$$(AB)^n = A^n \times B^n$$

Where the square root of a number is required, and where that number is greater than those tabulated in your handbook, why not factor the number to obtain values within the range of the tables?

Most tables in handbooks cover the numbers from 1 to 1000, if you need the value of, say, 1244 to the ½, it is equal to the product of the square roots of the selected factors. It is more convenient to choose one factor, such that its root is a whole number—in this case 4 does nicely.

If 4 is used, the other is 311. The square root of 4 is 2, and the square root of 311 is 17.6352; the required root is 2 × 17.6352 or 35.2704. Cases will be met in practice where the number for which the root is desired may not be factored; this does not rule out the method, but merely calls for a modification.

Take as an example the number, 7797, the square root of which may be found by logarithms, to be 88.3006. If the number is divided by 9 the result is 866⅓. Neglect the ⅓ and look up the square root of 866, which is 29.4279; the product of this value times 3 is 88.2837, which is in error by much less than 1 per cent.

In some cases it may be possible to use more than one pair of factors, but where this method is used, it is highly desirable to choose factors that are perfect squares, or cubes, as the case might be. The method suggested is probably of greater value for finding cube roots, than for square roots; because of the great difficulty in solving directly for the cube root.

THE USE OF FACTORS WILL GREATLY FACILITATE MANY CALculations. A good example is the term $(P_1^2 - P_2^2)$. This may be factored to $(P_1 - P_2)\ (P_1 + P_2)$. The powers required may often be taken from the tables following this separation into factors.

All of those formulae that the engineer uses may have the

numerical values combined, with definite reduction in the amount of labor required for the solution. Such values may include not only the constants appearing in the formula, but also, those variables that remain constant over a given set of calculations.

Examples of such variables might be the pressure and temperature bases in use on a given pipe line system, the specific gravity, the fugacity factors, and so on in a specific set of calculations.

The use of a pocket book is recommended. Set down in it the intermediate values found for use in the solution of your problems, and it will often result in your having a nearly complete set of solutions for a given set of conditions. Fill in the gaps and a valuable set of tabulated data results. This is especially true of pipe line flow calculations, the calculation of orifice meter coefficients, and the like. When you have a group of such calculations to make, a check should be made to find those terms common to all members of the group.

QUITE OFTEN IT IS NECESSARY TO MAKE USE OF FRACTIONAL roots that can only be found with logarithms. A familiar example is the determination of the pipe diameter required for a given gas flow rate over a stated distance, in this problem, if Weymouth's formula is used, the value of Q to the ⅜ power is required.

In designing a gathering or a distribution system, where various flow rates are to be considered, this may be much simplified by setting up a table of the various factors in your pocketbook. In design work, it is usually satisfactory to round off the volumes to the nearest millions of cubic feet, so if one finds and sets down the following, the calculation may be reduced to combining factors:

Q (flow)	d (pipe diameter)
0.1	in
0.25	this
0.5	
0.75	list
1.0	the
2.0	equivalent
3.0	pipe
4.0	diameter
5.0	required
6.0	for
7.0	the
8.0	given
9.0	gas
10.0	flow
100.0	rate
1,000.0	
10,000.0	
100,000.0	
1,000,000.0	

The desired value of Q is quickly found from combinations of these factors.

For a given design problem the base, or standard conditions, will be defined, and may be combined with the numerical constant. Any other terms may be handled as was suggested for Q. It will often be the case that the result is not to be used as an answer but as a guide, the determination of the pipe size referred to above is a good example.

It will rarely be found that the result of the calculation coincides with a standard pipe size. This being true, one may generally reduce the number of factors to that which will give reasonable approximations, rather than attempting to determine the exact value of, say, 19.7.

The use of factors to reduce the labor of division is often overlooked. For most, short division is performed much more rapidly than is long division. Yet, it is surprising how few engineers factor the divisor, in order to reduce a problem in long division to simpler short division problems. In such a case as 2568 divided by 168, isn't it much easier to divide successively, by 4, 6, and 7, than to write

```
      15.2857
  168)2568
      168
      ---
       888
       840
       ---
       480
       336
       ---
      1440
      1344
      ----
       960
       840
       ---
      1200
      1176
      ----
        24
```

Using the factors, it is written like this

```
4)2568
6)642
7)107
 15.2857
```

Comparing the two it appears ridiculous not to employ the simpler method.

IN MULTIPLICATION, THERE IS A METHOD THAT MAY BE USED to greatly reduce the labor required to obtain a product (correct to a required number of places) of two decimals. This method, called contracted multiplication, is much easier demonstrated than explained. A typical application might be encountered in determining the value of d, where d is equal to 11.938. The logarithm of 11.938 is 1.0769316, multiplying in the usual manner

```
  1.0769316
      2.667
  ---------
   75385212
   64615896
   64615896
   21538632
  ----------
  2.8721765772
```

The product will be rounded off to 2.8721766. Since only seven places are required in the product the contracted method may be used to obtain seven places only.

```
  1.0769316
       7662
  ---------
  2.1538532
    6461590
     646159
      75385
  ---------
  2.8721766
```

It will be noted that in this method the multiplier is written backward, and with its unit figure under the last decimal place of the multiplicand required in the product.

When the numbers are written in this manner, the product of any figure in the multiplier and the figure in the multiplicand directly above it will be of the same order of value as the last figure to be retained in the product.

For this reason the first figure of each of the products is to be placed directly under the last retained figure of the multiplicand.

In order to compensate for the part omitted, it is necessary to begin with the figure to the right of the one directly above any multiplier; this product is rounded off and carried; in the example, when the second figure of the multiplier, 6, is used, instead of saying 6 times 1 are 6 and writing down the 6, we first say, 6 times 6 are 36 and carry 4 to the product 6, this gives 10, so we write 0 and proceed in the usual way.

In the case of the last figure, 7, we first say, 7 times 3 are 21, then 8 times 9 are 63 and 2 to carry are 65, the 5 is written and we again proceed in the usual manner. As the number of figures in the numbers increase and as the number of places required in the product decrease, the advantages of this method obviously become greater.

If the cross sectional area of 12-in., schedule 40 pipe was required in the absence of a set of log tables and a calculating machine, and the result required to three decimal places, then this method would be of definite value. The factors are

$$11.938 \times 11.938 \times 0.25 \times 3.1416$$

If all of the decimal places were retained, there would be a total of 12 places in the product. We may use the contracted method as shown below and restrict the product to the desired three decimal places.

11.9380	142.515	35.629
83911	520	61413
119380	28503	106887
11938	7126	3563
10744		1425
358	35.629	36
95		21
142.515		111.932

Only a small amount of practice is required to become adept in the use of this method. Remember that the UNIT figure of the multiplier is to be written under the last decimal place to be retained in the product and the position of the decimal point will be fixed. Failure to place properly the unit figure will result in either more or less places than desired.

The same principle may be applied to the division of decimal numbers. In every division, the first figure of the quotient will always be of the same order of value as that figure of the dividend, under which is written the product of the first figure in the quotient by the units figure of the divisor.

Having determined the order of value of the first quotient figure, make use of as many figures of the divisor as you wish places of figures in the quotient. As an example, divide 754.347385 by 61.34775, and let the quotient contain three places of decimals:

```
61.34775)754.347385(12.296
         613 48
         ------
         140 86
         122 69
         ------
          18 17
          12 27
           5 90
           5 52
           ----
             38
             37
             --
```

In this case the first quotient figure had an order of value of 'tens,' so a total of five figures of the divisor was required. Each remainder is treated as a new dividend, and in each following division one figure to the right hand of the divisor is omitted; as in the contraction of multiplication it is necessary to carry for the increase of the figure cut off.

If you have any doubt of the advantage of this method, it is suggested that you work out the example in the usual manner and compare the two.

The work involved in division may also be approached by a combination of factoring and cancellation; a departure from the usual method of writing such problems will at times prove to be advantageous. Take such a problem as 9072 divided by 1512; this may be written as follows:

```
          6
      ----
21)126
8)108
9)9072
-------- = 6
9)1512
8)168
21)21
   1
```

The use of the familiar method of writing the problem and their solutions may not be best in every case. Whenever it is possible to use an alternate method with either an increase in accuracy, or ease in checking, such a change is justified. Use of the "accountants method" in addition is a good example.

```
89764
 3843
  474
 9639
-----
   20
  20
 25
21
8
-----
103720
```

It is apparent that setting down the sum of each column separately will allow a check for error to be made much more readily than is possible when the usual method is used. In the example used the advantage is not as evident as it might be where many numbers must be added, as might be the case in finding an average of hourly observations.

IN OBTAINING AVERAGE VALUES OF A SERIES OF OBSERVED data, there is a short cut which is not used as generally as it deserves. In those cases where the individual values do not vary greatly from one to the other, an assumed average, or base condition is selected and the departures from this base totaled; the average of the departure is taken, and applied to the base as indicated in the following example:

Observed	Assumed base	Diff.	Diff.
194	188	+6	+6
186		−2	−4
188		0	+4
192		+4	+8
189		+1	+9
187		−1	+8
195		+7	+15
189		+1	+16
187		−1	+15
188		0	+15
190		+2	+17
193		+5	+22

Average difference = 22/12 = 1-5/6
Average for period = 188 + 1-5/6 = 189-5/6

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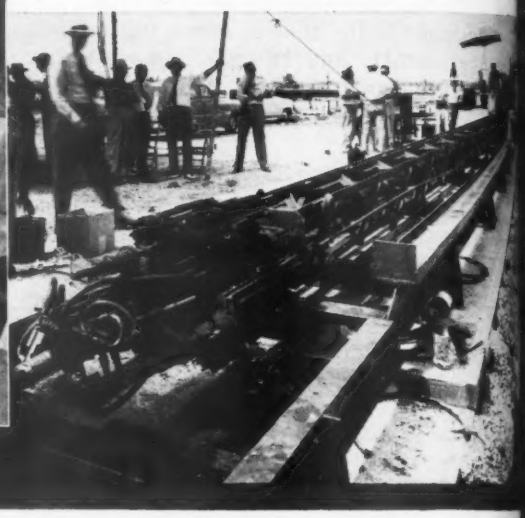
LINE

The heart of the C-R-C internal cleaning and coating machine is this head which rotates at 250 rpm. The wire brushes clean the pipe and corrosion-resistant coating is sprayed from the guns at the left.



This over-all view shows the rotating head and the shaft which drives it through the pipe.

The rotating head enters the pipe after it has been clamped on the rack to begin the cleaning-coating operation.

This tractor drives the cleaning head through the pipe. Coating for the spray guns is in the tank in front of the operator.

Increased production through improved flow in your pipelines is now possible with the use of C-R-C's revolutionary new internal cleaning and painting machine. This new machine cleans the interior of the pipe and coats it in one automatic operation. Internal cleaning gives a smooth abrasion-resistant surface resulting in reduced turbulence and friction for substantially increased flow.

After the cleaning operation the machine coats the interior with a corrosion-resistant Epon* resin paint, developed in cooperation with Coast Paint & Lacquer Co., Inc. The unit is designed to provide pipe joints with this smooth interior surface and protective coating when they are received from the mill. Its use is also recommended on pipe that has been in storage for long periods to remove rust and corrosion before it is laid.

The new unit is an EXCLUSIVE* development of C-R-C. It is completely portable and can be used for stationary or on-the-job installations. The cleaned and coated, abrasion-resistant surface is desirable for use in gas pipelines as well as products and crude-oil lines. Consult C-R-C on this new pipeline development for improving production in your lines.

*Patent pending

C R C

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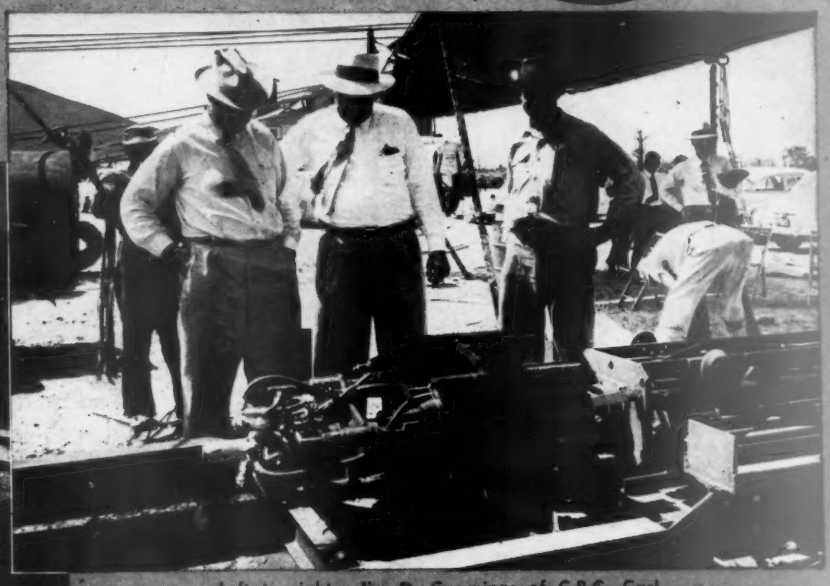
C-R-C has been First with every major development in pipeline equipment

XUM

DEVELOPMENT AND COATING OF PIPE

A supply of 5-gallon cans of special "Copon" formulated for C-R-C pipe application.



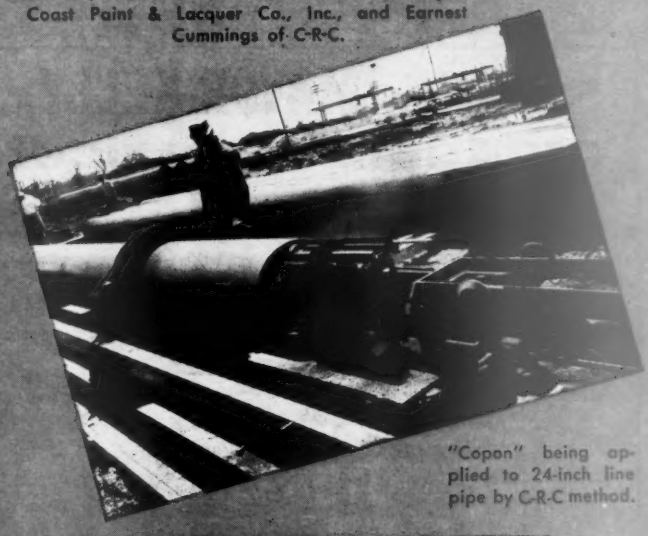
Left to right — Jim D. Cummings of C-R-C, Carl Seefeld, Vice President and General Manager, Coast Paint & Lacquer Co., Inc., and Earnest Cummings of C-R-C.

"COPON" . . . our Epon® resin coating is used by C-R-C for protection and preservation of line pipe.

Our chemists and engineers — working for weeks in close association with Mr. Jim Cummings — have developed and perfected the special "Copon" formula for the coating used in the revolutionary new C-R-C line pipe cleaning and coating process.

"Copon" adds years to the life and usefulness of line pipe.

- **It assures installation of rust-free pipe.**
- **It has exceptional tenacity, will adhere to metal surfaces longer and under more difficult conditions than any other coating yet tested.**
- **It is abrasion-resistant and has proven low erosion rate.**
- **It gives positive protection against rust and corrosion, also the chemical effects of crude oil, natural gas and salt water.**
- **It has amazing flexibility and elasticity.**
- **It provides a silky smooth, even surface that increases line flow by reducing friction.**



"Copon" being applied to 24-inch line pipe by C-R-C method.

Above the business end of C-R-C cleaner and "Copon" application.

COAST Paint & Lacquer Co. Inc.

P. O. Box 1113 Houston, Texas

Specializing in Protective Coatings and finishes for Industry

Average difference = 22/12 = 1⅚
Average for period = 188 + 1⅚ = 189⅚

The value of the assumed base may be taken at which every value seems convenient to the calculator, the more nearly this base approaches the correct average the smaller the total difference will be. If the exact average is chosen this value will be zero. In the example above, had the base been taken as 190, the total difference would have been minus 2, and the average for the period found from

$$190 - \tfrac{2}{12} = 189\tfrac{5}{6}$$

This method is particularly advantageous in averaging the data on a plant log sheet, or in finding average conditions from a flow meter chart.

WITH REFERENCE TO FLOW METER CHARTS, IT IS STRICTLY true that the average square root and the square root of the average are not of the same value, and may under some conditions differ considerably. Analysis of a few charts will serve as a guide, two typical cases are given to illustrate:

Hourly reading	Square root
57	7.550
58	7.616
60	7.746
61	7.810
59	7.681
56	7.483
54	7.348
53	7.280
58	7.616
59	7.681
60	7.746
63	7.973

The average of the hourly readings is 349 divided by 12, or 58.166. The square root of the average in this case is $\sqrt{58.166}$, or 7.6266.

The average square root is 91.530 divided by 12, or 7.6275.

There is little evidence in this case to support the rule that square roots of the individual hourly readings must be taken. Other sets of readings may produce results which make adherence to the rule mandatory. Each case should be considered on its own merits and the calculator's use for the value he obtains. Consider the following series of readings:

Hourly reading	Square root
20	4.472
75	8.660
10	3.162
15	3.873
80	8.944
60	7.746
90	9.487
18	4.243
28	5.292
30	5.477
45	6.708
72	8.485

The average of the hourly readings is 543 divided by 12, or, 45.25. The square root of the average is 6.7268. The average square root is 76,849 divided by 12, or 6.404.

In this case the difference, which amounts to about 5 per cent, may rule out the use of the square root of the average. If the calculation is for rough field use only, this error may not be considered serious. The man at the spot must decide the degree of accuracy required. Where pin point accuracy is not essential there seems no reason for performing the labor required by strict adherence to the rules. * * *

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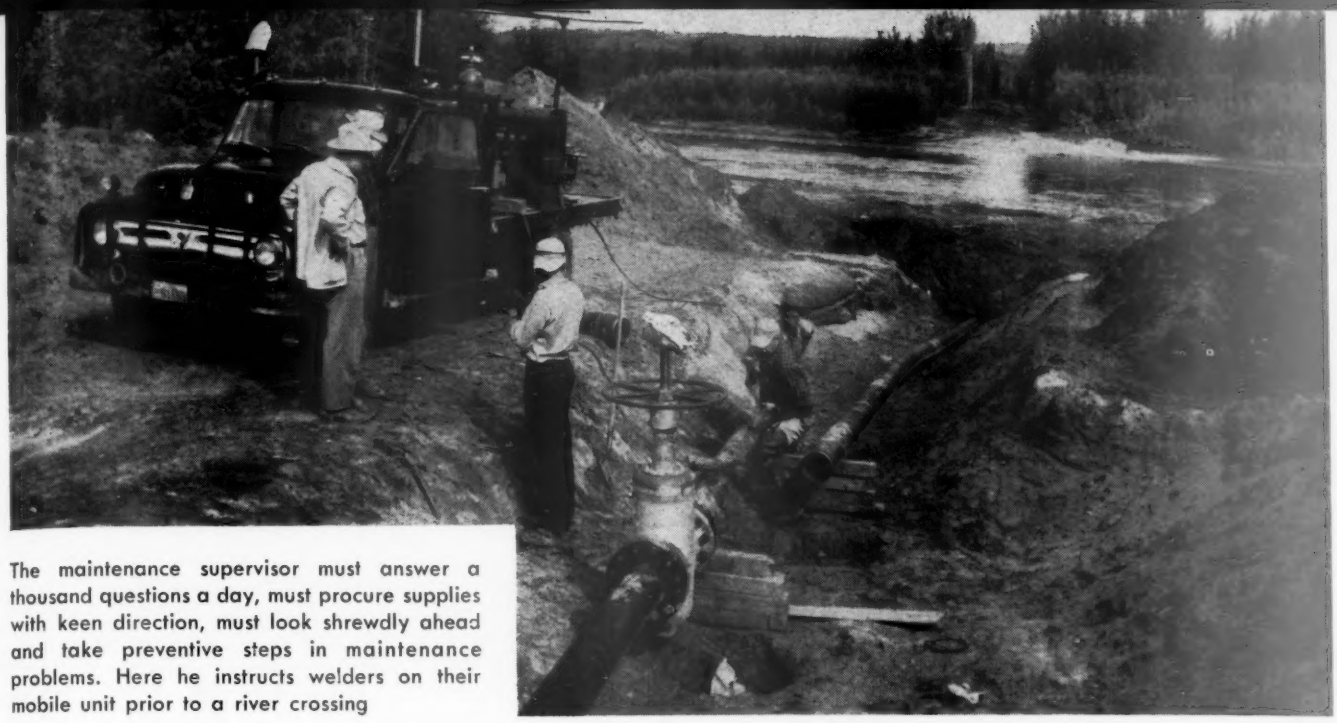


The maintenance supervisor must answer a thousand questions a day, must procure supplies with keen direction, must look shrewdly ahead and take preventive steps in maintenance problems. Here he instructs welders on their mobile unit prior to a river crossing

Modern Equipment Maintenance
One of a Series

P 880.1

Procurement, prevention, and repair are his job; on him depends the prevention of costly equipment downtime

The Maintenance Supervisor

R. R. Bessler

RIDING along in a pickup over a freshly dozed trail, jockeying the wheel with his left hand to avoid soft spots, the maintenance supervisor uses his right hand to answer a call on his radiotelephone. "KSA462, Burk here. Go ahead, John. Over."

The radio speaker blares out in a seemingly unintelligible squawk, but Burk's trained ear sorts out the message. A few selected questions are necessary to learn that the dozer clearing for the right-of-way 20 miles ahead in the bush country is overheating and the operator is only getting half his work done. The dragline at the "rock cut" has a break on one side of the bucket and needs welding immediately. "Shorty" just called in to say that two track rollers need replacing on the pipelayer in Section 2. Another dozer is needed on the incoming haul road to clear out some slides, and if there is another tractor available, one is needed to help pipe trucks through the muddy stretch at "Ten Mile."

It is a big job this fellow has, one that requires a lot of skill, planning, tact, and patience. Although he can probably weld the bucket, replace the rollers, correct the overheating prolem on the dozer and put new brushes in the generator, time and distance will not permit one man to accomplish all this work at once.

Basically, his job consists of three things—procurement, prevention and repair. More specifically, he must procure enough suitable equipment to keep the many facets of a pipe line job operating. He must procure parts, lubricants and fuels to keep the many machines operating almost continuously.

He must establish contacts with local machinery dealers to be sure they know the types and serial numbers of machines he is using so that they can stock emergency parts for those machines. He could unwisely tie up large amounts of money in spare parts when a nearby dealer would gladly stock them. A wise supervisor will invest such finances in adequate facilities such as service and grease trucks manned by competent and conscientious mechanics and troubleshooters.

His job includes establishing, supervising and enforcing a suitable preventive maintenance program to prevent costly and lengthy periods of equipment downtime. For the more popular types of equipment, he draws on the skills and facilities of the local equipment dealers and saves his own mechanics for troubleshooting on the more complex machinery for which local service is not always available.

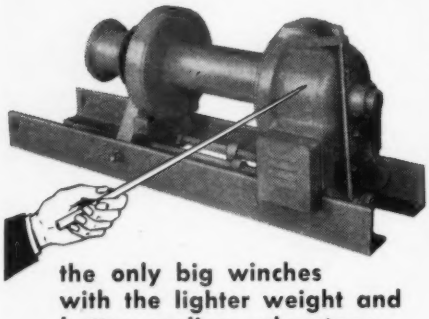
His preventive maintenance program, if it is adequate, has already warned him that the dozer pioneering in the brush needed a new fan belt, and a man is already on the way to install it. He has asked the local equipment dealer to bring special tools to turn the collector ring on the generator, a small job, but one for which the maintenance supervisor does not have the proper tools and equipment. He has a set of new or rebuilt track rollers ready so that they can be used to replace worn out rollers during idle periods.

His preventive maintenance program is a well-planned one scheduled from the "operator's instruction book" supplied by the manufacturer. There is no guess work, no short cuts, no omissions. He realizes that the manufacturer wrote the book and made recommenda-

EXCLUSIVE

NEW

12,000 and 20,000-lb. Gar Wood Winches



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Maintenance supervisor keeps in touch with the entire line employing his radio-telephone. Although he is well qualified to handle any emergencies personally, time and distance prevent his being on the spot when a breakdown occurs. He uses his broad knowledge and experience to direct activities to his trouble-shooters

tions that are the result of research and vast experience gained by noting what has proved to be successful for pipe line users all over the world.

He knows that his time can be better spent enforcing a rigid preventive maintenance program and that is how he spends it. He could be the welder, the greaser, the mechanic, operating engineer, parts hauler and purchasing agent, but the efficient maintenance supervisor directs his operation and lends his knowledge by supervision.

He is rewarded day by day as he watches huge machines trundle over the ground, clearing roads and right-of-ways, while others follow to open up the earth or carry huge sections of pipe. Other machines follow to lift the pipe, wrap and coat it, and lower it beneath the earth where it is buried to later become the life line of an industry, or perhaps an army, navy or air force.

When the occasional breakdown happens, he investigates the cause, learns the reason and applies it to his already broad experience. Methods of prevention develop and are put into practice. His program expands as does his supervisory efforts.

Time is the most precious element the maintenance supervisor has, because there is so little of it to devote to every operation of his complex job. His experience and knowledge is much broader than that of his men and he devotes that time which might be spent assisting on a repair job in training his foremen and mechanics in the methods he himself would employ.

Certainly his operation is more efficient when his knowledge and experience are communicated to many men.

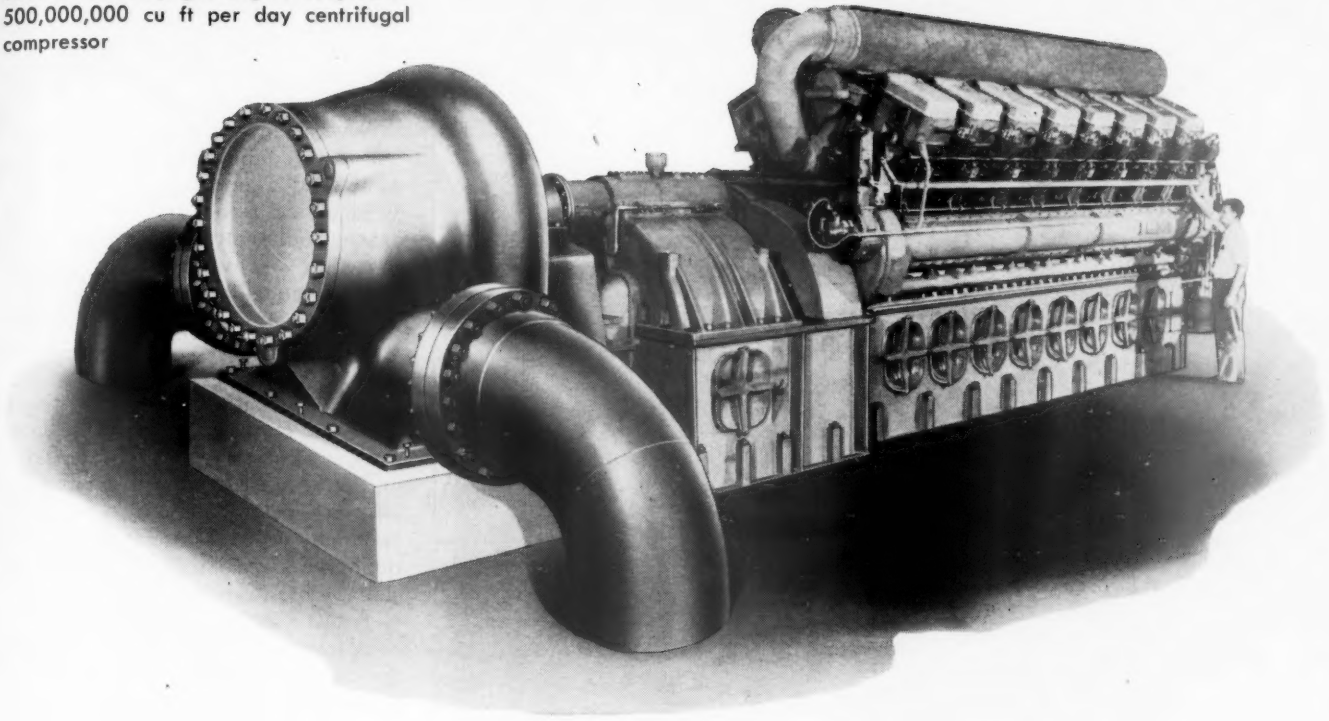
* * *

The Author

R. R. Bessler, assistant service manager, Caterpillar Tractor Company, joined the company in 1935 as a four-year machinist apprentice. He was graduated in 1939 and was a foreman when he left in 1943 to serve with the United States Marine Corps. After World War II, he entered the service department where he became service training supervisor until he resigned to manage a Caterpillar dealer's service organization. Returning to Caterpillar in 1948, he was assigned as service representative assisting dealers in the Northwest.

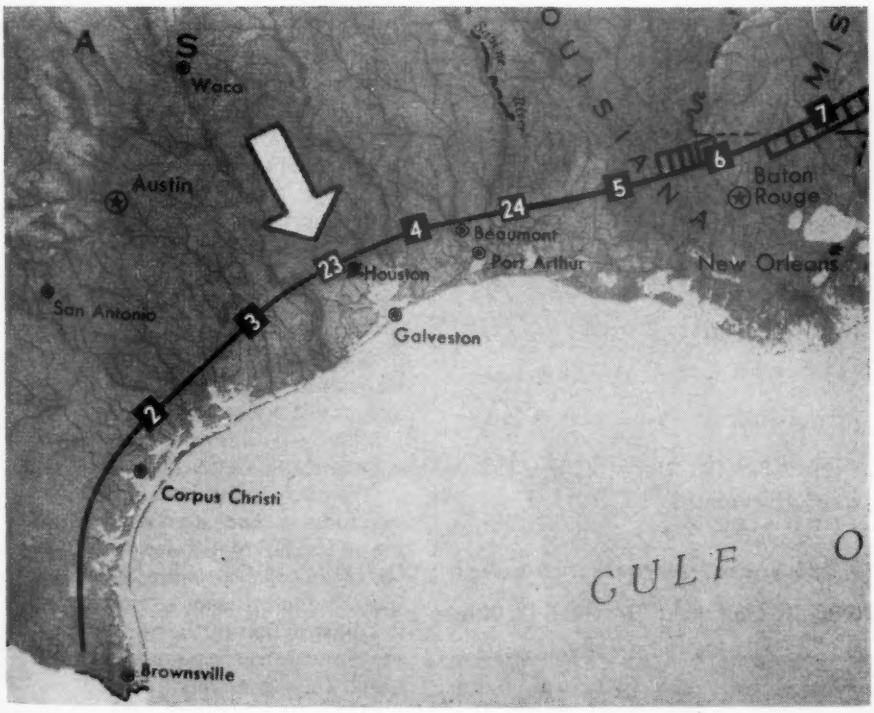
In 1953 he completed a special assignment with the Armed Forces in Korea and Japan. Upon his return to the United States in November, 1953, he was appointed to his present position.

View of 3000-hp gas engine coupled to 500,000,000 cu ft per day centrifugal compressor



Transco to Install First Engine-Centrifugal Station

Dean Hale*



Arrow points to Station 23, near Houston, Texas, where the intermediate station will be added to Transco's main line

As part of its 1955 expansion program that will boost daily system capacity approximately 130,000,000 cu ft, Transcontinental Gas Pipe Line Company will construct a new booster station in Texas that will involve a new concept in gas compression equipment.

The station, to be known at Station 23, will be located in Harris County, Texas, near Houston, approximately midway between the company's present Stations 3 and 4.

Chief interest in the new intermediate station centers around the installation of a V-type reciprocating gas engine driving a centrifugal compressor, the first unit of this type installed by a major gas transmission company.

The prime mover is a 16-cylinder, V-type, super-charged, spark ignition gas engine.[1] Rated 3000-hp at operating speed of 470 rpm, the engine will drive a single-stage centrifugal compressor through a speed increasing gear of 10:1 ratio.

The compressor,[2] designed for 500,000,000 cu ft daily capacity, will initially be operated at approximately 475,000,000 cu ft daily capacity. Station suction pressure will be 622 psi and discharge will be 702 psi at a compression ratio of 1.15.

*Editor, Oil . . . Gas . . . Products Pipelining edition.

[1]The Nordberg Supairthermal turbocharged engine is capable of carrying 3550-hp at 500 rpm continuously.

[2]DeLaval centrifugal compressor.

The Cleveland "190"—a Real Backfiller One-Man-Operated, It's Smooth and Fast

PIPELINE CONTRACTORS are establishing new standards of fast, economical performance with the big-capacity Cleveland Model 190 Backfiller on the largest pipelines. It's paying off on the smaller lines, too.

The "190" backfills and travels simultaneously—in either direction. Accurate control of the 7-ft., well balanced, 1,000 lb. board is provided by responsive, easy acting, long lived, hydraulic clutches.

Operators like the "190" because it allows full visibility of the work, and its easy-working levers are grouped just right for better backfilling from start to finish on every shift.

The "190" effectively employs low ground-bearing pressure and proper balance *(proper balance from side to side and end to end)* on wide non-packing crawlers that are 100% anti-friction-bearing mounted. It's swift and sure whether working in mud and sand, in swamps or over the hills.

It's designed and built *from the ground up* to do all your backfilling—better, faster and at lower cost. It's a *Real* Backfiller—It's a *Real* Cleveland.

Want more information on the "190"? See your Cleveland Distributor!

THE CLEVELAND TRENCHER COMPANY • 20100 St. Clair Ave., Cleveland 17, Ohio

CLEVELAND

Located approximately 65 miles downstream of Transco's El Campo station, a new unit will serve to increase daily throughput of the system in accordance with the company's expansion program.

Several unusual features distinguish this new equipment. The engine bed plate and frame are fabricated of welded steel rather than the cast bedframe commonly used, giving advantages in lower weight per hp and subsequent reduction in foundation design requirements. Cylinders are individually cast and connecting rods are the side by side type.

Another feature is the mounting of the speed increasing gear set on an extension of the engine bedplate, giving an integral structure throughout and allowing better alignment of shafts. Distinctly different also is the use of a quill-type drive shaft to reduce torsional vibration.

Transco is installing the unit as a pilot model for studies into operating and maintenance costs. By using a reciprocating gas engine with a centrifugal compressor, the unit combines the advantages of a highly efficient type of prime mover with those of a compressor that has gained acceptance in applications where large quantities of gas are compressed at low compression ratios.

The gas engine prime mover generally has a lower fuel consumption and better thermal efficiency than other types of prime movers. It also has advantages of low lubricating oil consumption, compactness, and low water requirements.

Centrifugal compressors provide high efficiency at low compression ratios, are easier balanced because of their rotary motion only, give continuous flow without pulsation, and generally have lower maintenance and lube oil consumption because of fewer moving parts.

The operating characteristics of such a combination lend themselves well to the booster station installation required by Transco. Needed was an intermediate station that would give increased line capacity at a low compression ratio, be economically practical in relation to amount of equipment installed and operating costs, and personnel required to maintain the station.

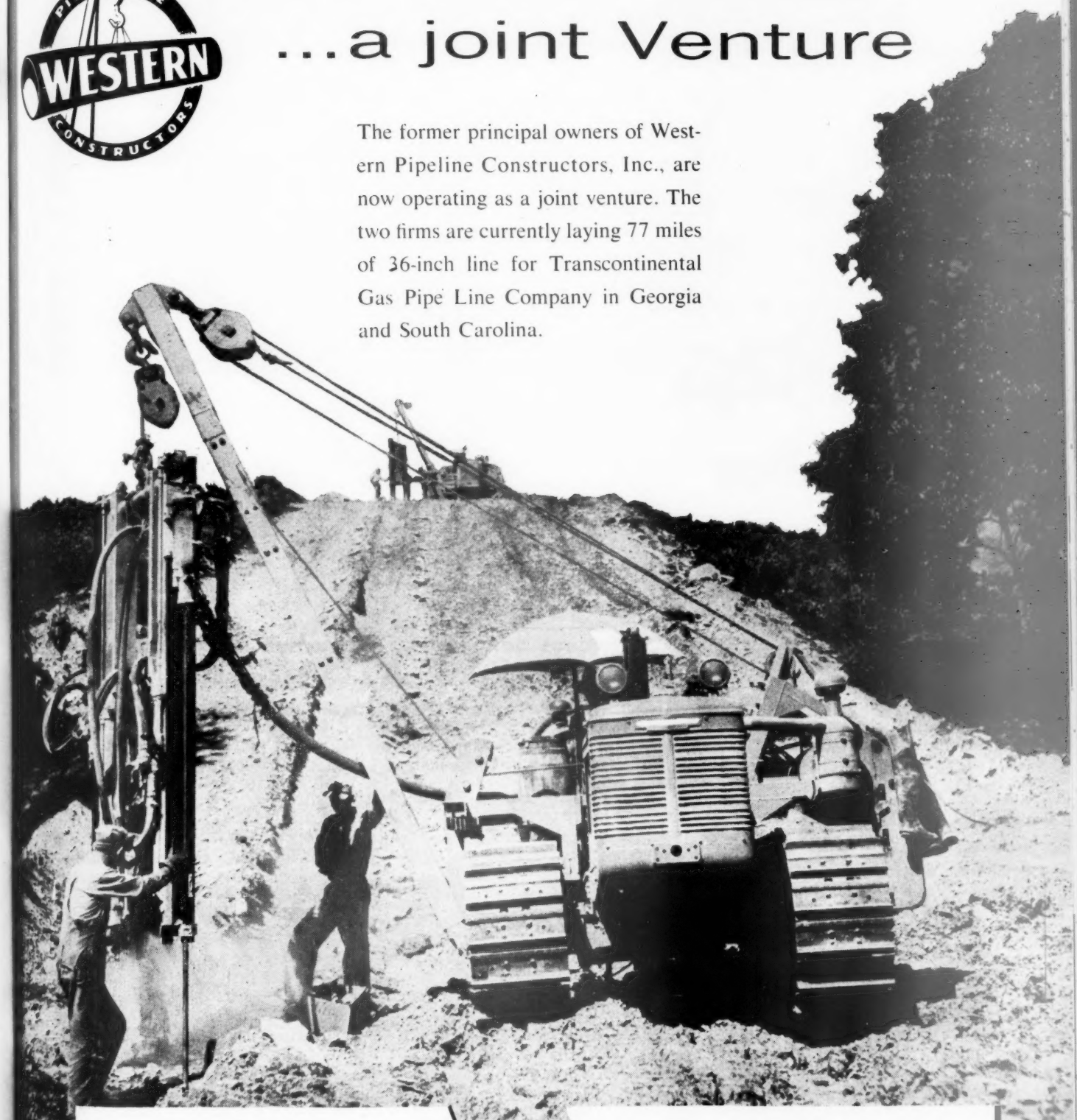
Transco's pilot installation will be carefully studied after it goes into operation. The results may bring about some concepts in equipment for large capacity compressor stations.

Construction of the Station 23 is expected to get underway in late June or early July and completion is scheduled for October this year, when the company's expanded facilities go into full operation. * * *

PIPE LINE WESTERN CONSTRUCTORS

...a joint Venture

The former principal owners of Western Pipeline Constructors, Inc., are now operating as a joint venture. The two firms are currently laying 77 miles of 36-inch line for Transcontinental Gas Pipe Line Company in Georgia and South Carolina.



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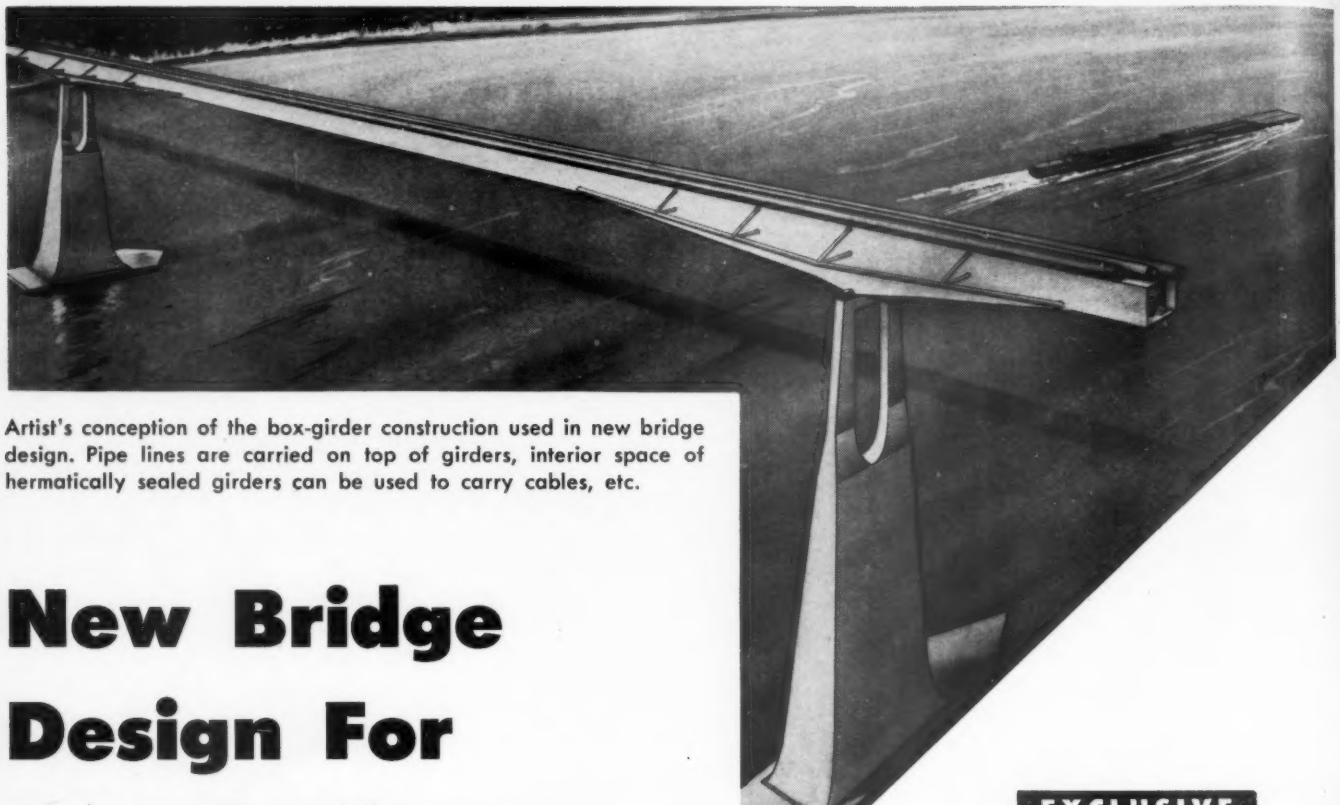


Artist's conception of the box-girder construction used in new bridge design. Pipe lines are carried on top of girders, interior space of hermatically sealed girders can be used to carry cables, etc.

New Bridge Design For Tough Rivers

EXCLUSIVE

Continuous box girder construction coordinated with complete support system promises economies in time and money plus safety factor on difficult crossings

Dean Hale*

A NEW type of bridge has been developed that may well revolutionize the crossing methods employed by pipeliners for such difficult streams as the Mississippi, the Missouri, and other major waterways across the country.

This bridge could eliminate the many difficulties experienced by pipe line companies who have installed major crossings during the past 20 to 30 years. Approximately two-thirds of the major Mississippi River underwater crossings have required major repairs or complete replacement in this period. This expense coupled with the uncertainty of operation constantly threatening the pipe line owner may now be a thing of the past.

There are all kinds of explanations telling why a crossing went out, why scouring took place at a particular point, how backfilling was done improperly, how the line was laid too shallow, how the shifting current affected this or that part of the line—but very little comment is made about the fact that all these crossings from design to final construction completion, were based on assumptions made by men who had no power to control the elements that affected these assumptions.

With this new type of structure, the design engineer and the construction groups are practicing principles and procedures based on assumptions that have been proved to be correct and reliable. This new bridge design is presented as replacements for the crossing on which, for large and swift flowing rivers, assumptions have been wrong *many* times and on which costly and dangerous failures have occurred. They propose to do this at equal or less cost than that of crossings recently installed under water.

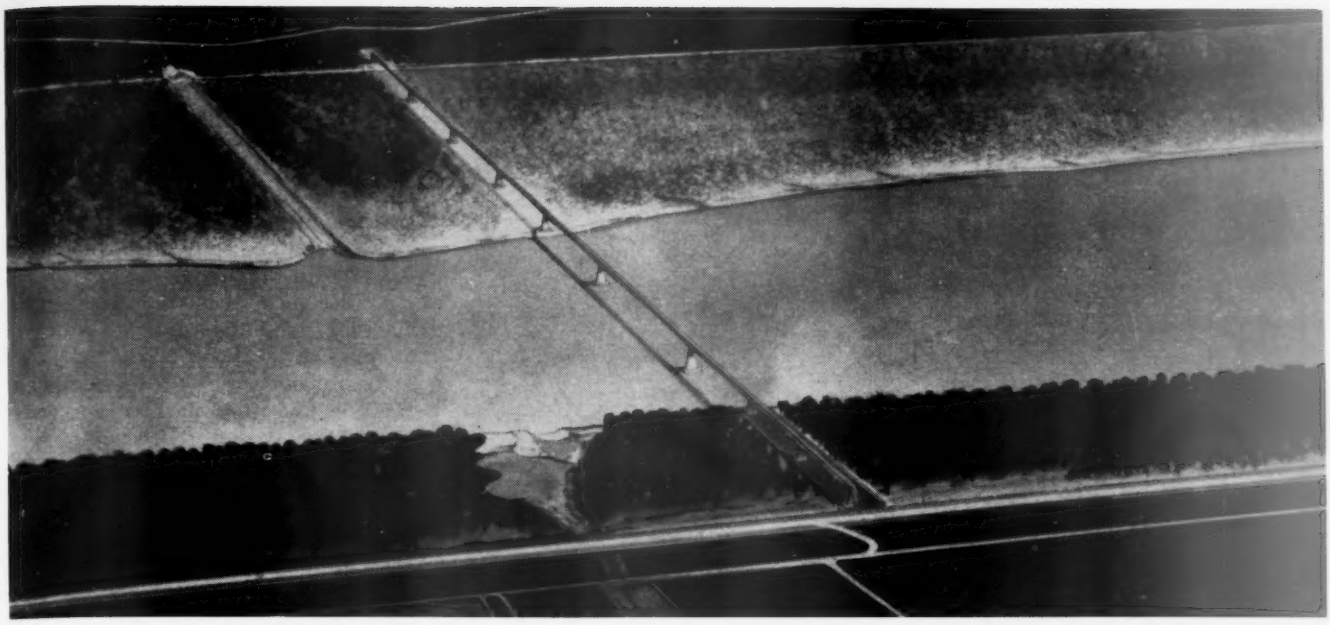
Using the new T-1 type steel, which is four times as resistant to corrosion and approximately three times as strong as normal structural steel, the bridge design employs box girders that will be hermatically sealed. The specially designed girders and the complete support system will be coordinated to form a continuous beam structure. The intricacies of design and doubtful action of forces and their applications, found in many of the present pipe line bridges today, are eliminated in this type of bridge.

The designing and construction firm currently is presenting design calculations and construction procedures that illustrate the advantages this structure has. In many ways, the continuous box girders complement the foundation and pier functions instead of creating extra burdens often recognized on bridge structures today.

In the planning stage is the first bridge of this type to be constructed over the Mississippi River. An artist's conception is shown in the accompanying illustrations. Designed to carry

*Editor, Oil . . . Gas . . . Products Pipelining.

XUM



Here's how bridge would look across the Mississippi River near Greenville, Mississippi. To left of bridge is underwater crossing.

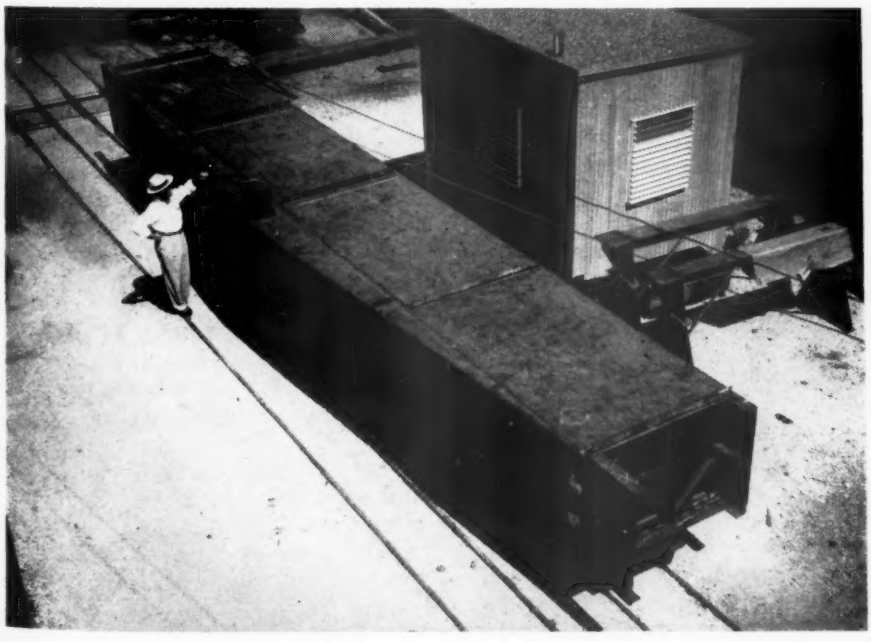
three 30-in. pipe lines, the bridge has a total length of 6050 ft, using a center span 850 ft in length, with other spans each 650 ft in length. The bridge has a clearance of 115 ft above mean low water level. Girder width on top is 8 ft, maximum girder depth is 16 ft, and minimum girder depth is 8 ft. The bridge is designed to withstand wind loads 130 miles per hour or greater.

An additional advantage of using the hermatically sealed box girders is that the owner company could lease the interior space for carrying coaxial cables, telephone cables, or other lines. The bridge can be built over the Mississippi River says the design firm, Clear Span Engineering Company of Houston, Texas, for the same money that an underwater crossing of the Mississippi can be made, even with the conventional high strength steels. In many cases, this type of bridge can be built for considerably less than a conventional underwater crossing, particularly where T-1 steel is used.

The size of the bridge spans and the unusual construction make maintenance and expansion simple. Lines can be added, repaired, replaced, or removed without taking the bridge out of service. Carrying capacity of the bridge can be increased approximately 50 per cent at a cost of only 10 per cent of original cost. This means the bridge can be built to carry one line, then another line can be added for approximately 10 per cent of the original cost, and then still another line can be added for only 10 per cent of the original cost again.

Construction time required to build such a bridge over a stream as large as the Mississippi is estimated at approximately five months. This factor alone will justify the bridge in many cases. One unusual feature of the new design is that a bridge contract with the firm presenting the structure includes complete engineering services, complete construction, an insurance policy on the completed structure, and maintenance for any period desired by the owner. With the element of risk removed by the solid and dependable features of this bridge, the producers of the bridge are offering services that cannot be obtained for any other type of pipe line crossing known to exist today.

Box girder sections similar to the 40-ft highway bridge unit pictured here, are shop-fabricated, and shipped to job site where complete spans are assembled.



Fabrication of the bridge originates in the shop, where sections of the spans are mass produced. The T-1 steel used has a yield strength of 90,000 psi. Sections are shipped to the job site where complete spans are assembled and the bridge erected. No false work is required during construction and obstruction to traffic in the main navigation channel is insignificant.

The key to the low cost of construction of a bridge of this type lies in the girder assembly methods and in the methods of setting piers. The foundations and the pier superstructures have been used and tested for service much more severe and hazardous than that imposed by a pipe line crossing. The basic features are in use and have been in use for years on the hurricane tested offshore platforms used in offshore oil drilling, and on many highway bridges throughout the country. * * *

J. H. Mitchell

Locate Right-of-Way The Modern Way

Airplane and camera unite to save time and lower costs for engineers and contractors in pipe line construction

BY means of aerial surveys and photogrammetric procedures, the problem of locating an economic pipe line route has been greatly facilitated. The general procedure outlined below has been successfully used on recent major projects and has afforded substantial economies not only in the actual locating of the pipe line but also in the organization, planning, and administration of the entire project.

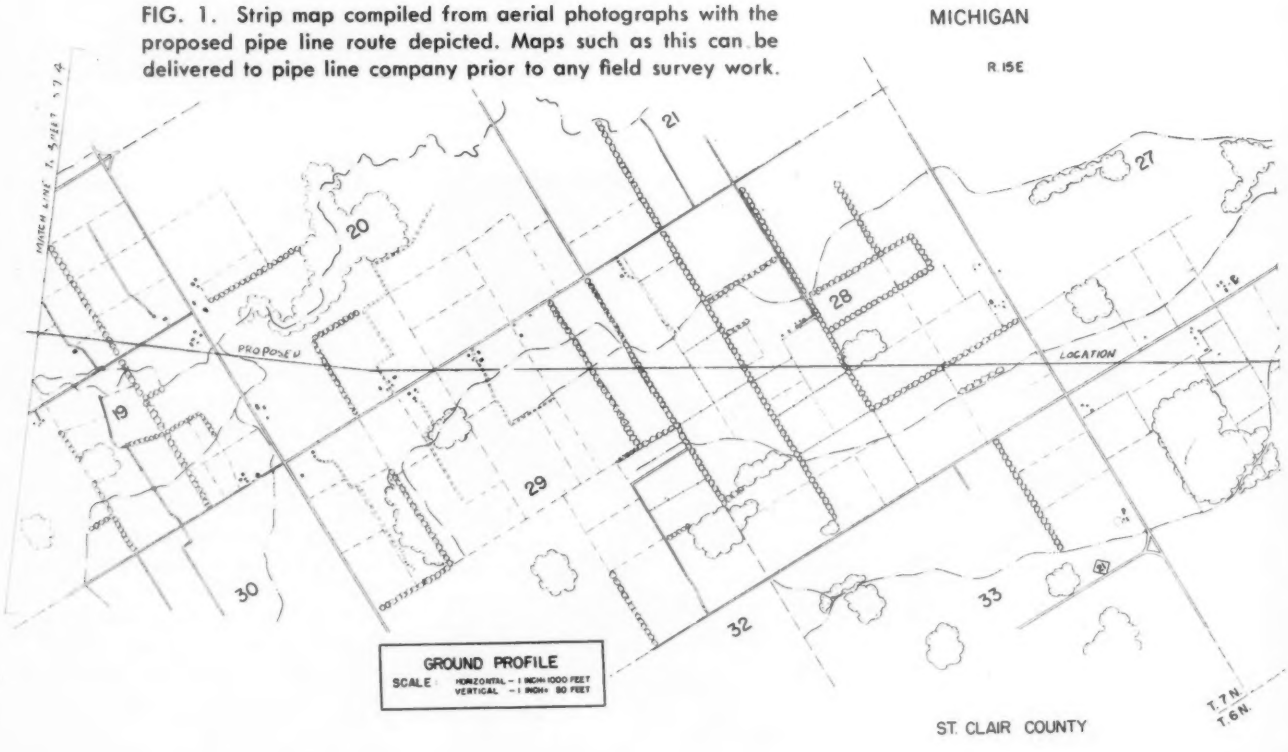
Reconnaissance. With the terminals of a pipe line established by economics and market studies, the general intervening route must be established.

This first phase of route selection serves only to determine the major obstacles that must be contended with or avoided, such as large bodies of water, cities, mountain ranges, solid rock outcrop, and the like. By making a detailed study of all existing maps and charts and supplementary air and ground reconnaissance, the general route is determined.

Aerial Photography. The general route is then photographed with a precision mapping camera from an altitude of about 10,000 ft in order to produce a set of 9 by 9-in. photographs providing stereoscopic coverage of a three-mile-wide strip at a scale of 1600 ft = 1-in. The altitude may be varied to obtain larger scale photography of built-

EXCLUSIVE

FIG. 1. Strip map compiled from aerial photographs with the proposed pipe line route depicted. Maps such as this can be delivered to pipe line company prior to any field survey work.



XUM

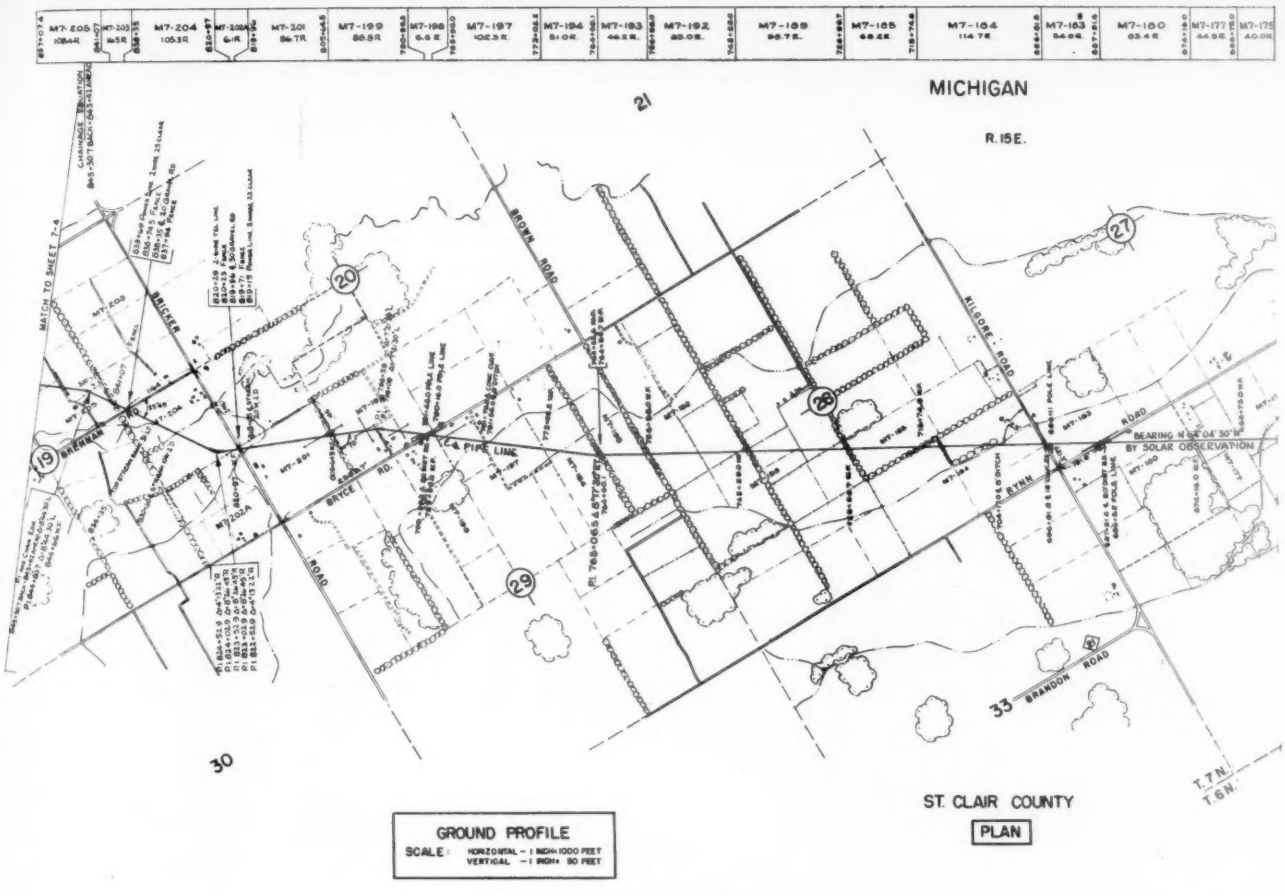


FIG. 2. This map is the same basic map as Fig. 1 but has incorporated the information obtained by the field survey parties. Staked line crosses essentially the same tracts as the "proposed" location line.

up areas if desired. Generally, however, it has been found that a photo scale of 1600 ft = 1-in. is most desirable for cross-country pipe line work and facilitates the following described mapping at 1000 ft = 1-in.

Study of critical areas. A detailed study of all critical areas such as river crossings, canyons, or populated areas may be made by projecting these photographs through stereoplotting instruments into a three-dimensional view. Here, experienced pipe line engineers can observe the problem area in true scale and in three dimensions and select the most feasible location from a construction view point.

Having determined the proposed location at the critical areas, the intervening route is then selected by means of a stereoscopic study of the remaining photographs. This study is made by an experienced pipe line location engineer familiar with the use of aerial photographs and experienced in photo-interpretation. The route selection thus made can be accomplished rapidly and irrespective of weather conditions and travel distances. The resulting location has proved to require a minimum of field revisions.

Stereo-Compilation. Strip maps of the entire route are compiled in the stereoplotting instruments covering a three-mile-wide strip and at a scale of 1000 ft = 1-in. As the man preparing the maps has before him a three-dimensional view of the terrain, it is possible to incorporate on the resulting map all physical features that could be of interest to the engineers, contractors, or right-of-way agents.

On these maps is projected the proposed line location as selected by the aforementioned stereoscopic study, as well as planimetric detail such as houses, fences, railroads, roads, crop lines, wooded areas, swamps, telegraph lines, streams, etc. The finished map is to accurate scale and all features are in their true relative positions.

Where there is sufficient existing vertical control or where it can be economically established, an accurate profile of the selected route can also be extracted from the stereoplotting instruments. Where rugged terrain warrants, contour lines can also be added to these strip maps.

Uses. The maps thus compiled supply the entire pipe line organization with a complete set of accurate maps depicting the proposed location, at the outset of the project and before any personnel have entered the field. Though no angles or dimensions are noted on these maps they are in effect "final" maps since distances and angles can be scaled and protracted from them.

A complete set of maps is supplied to the right-of-way agents, the contractors, the field survey parties and engineering offices. The following purposes are served by relying on the stereocompiled strip maps.

1. *The right-of-way department* can begin immediately to procure easement options along the entire route without awaiting field stake-out of the line. Also they need not purchase a swath of options since they can see in advance what properties will be crossed.

2. *The accurate projection* of this selected route provides a sound basis for the immediate obtention of clearing permits from governmental agencies, such as State and National Forest lands.

3. *The field survey parties* have detailed plans as to where the line should be staked. This eliminates cutting trial lines and reserves the location decisions to the qualified engineer who made the stereoscopic study in the office. Field decisions by the party chiefs and locators are consequently held to a minimum.

4. *Plan and cross-section information* for all highways, railroads, and river crossings can be obtained far in advance of centerline survey. This allows permit drawings for such crossings to be made and applications to be submitted at the earliest possible date.

5. *The scale of the strip maps* serves as a check on the field survey information, and as the field notes are sent into the drafting office the maps are converted from "proposed' to "as staked" by merely replotting the line location in accordance with the staked-out notes and adding the chained measurements and angles turned by the field survey crews.

The strip maps first produced provides the pipe line organization with a standard set of maps, eliminating the confusion attendant to the use of a miscellaneous collection of photos, road maps, charts, geological maps, county maps, etc.

The final "as staked" maps contain a wealth of information not normally contained in the usual pipe line right-of-way map. Such information is of considerable use in the letting of contracts during the construction period, and also to the maintenance and operating personnel throughout the life of the pipe line. * * *

The Author

John H. Mitchell is director of the pipe line division of Lockwood, Kessler & Bartlett, Inc. of Great Neck, New York. He joined the firm several years after being graduated from Lafayette College.

He spent a year in Vancouver, B. C., as assistant project manager when his firm was engaged in location surveys for the Trans-Mountain Pipe Line Company. In 1953 he was project manager in charge of location surveys and mapping on the Lakehead pipe line extension.

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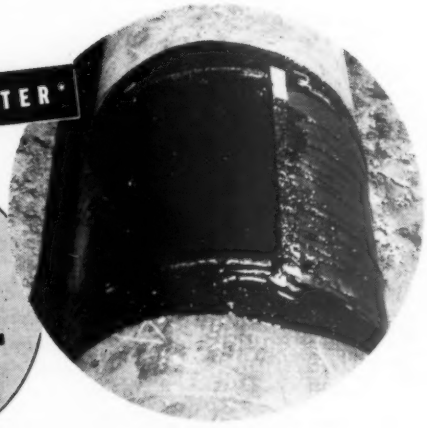

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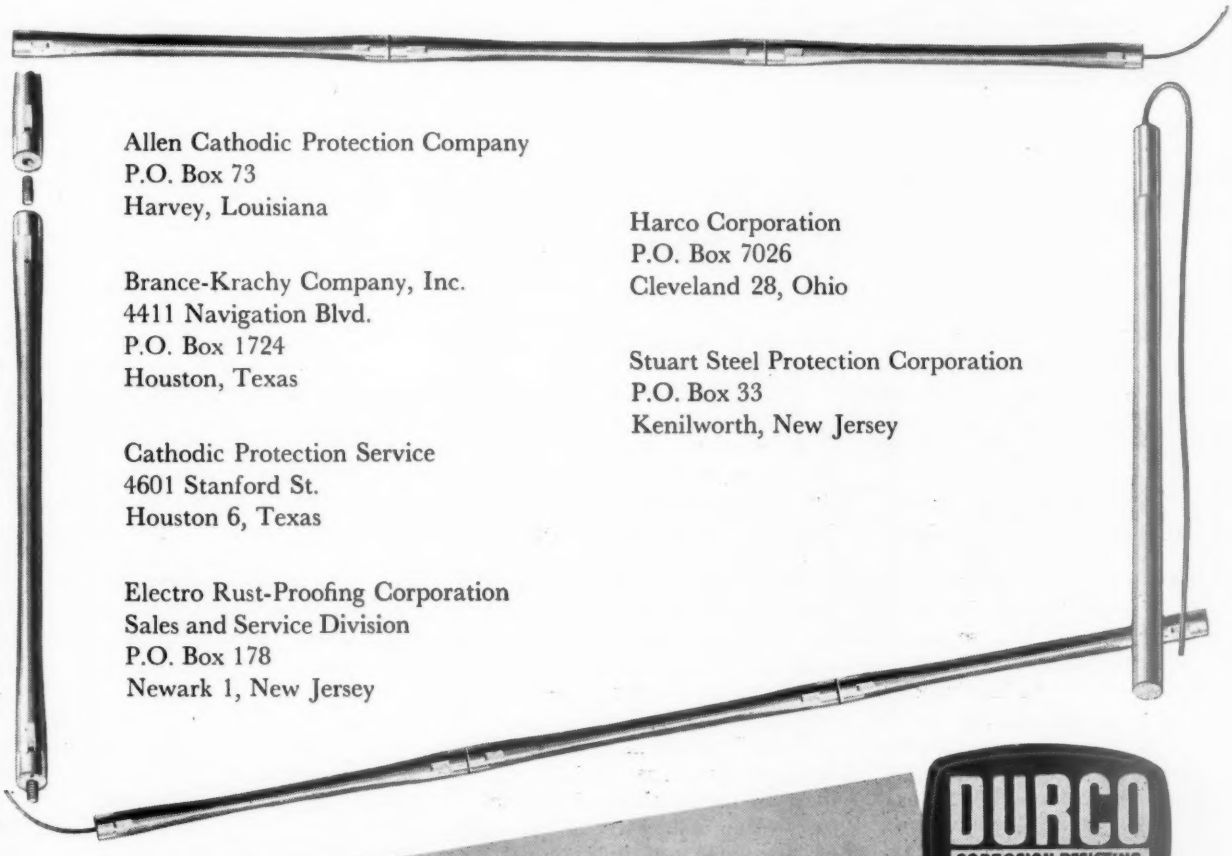

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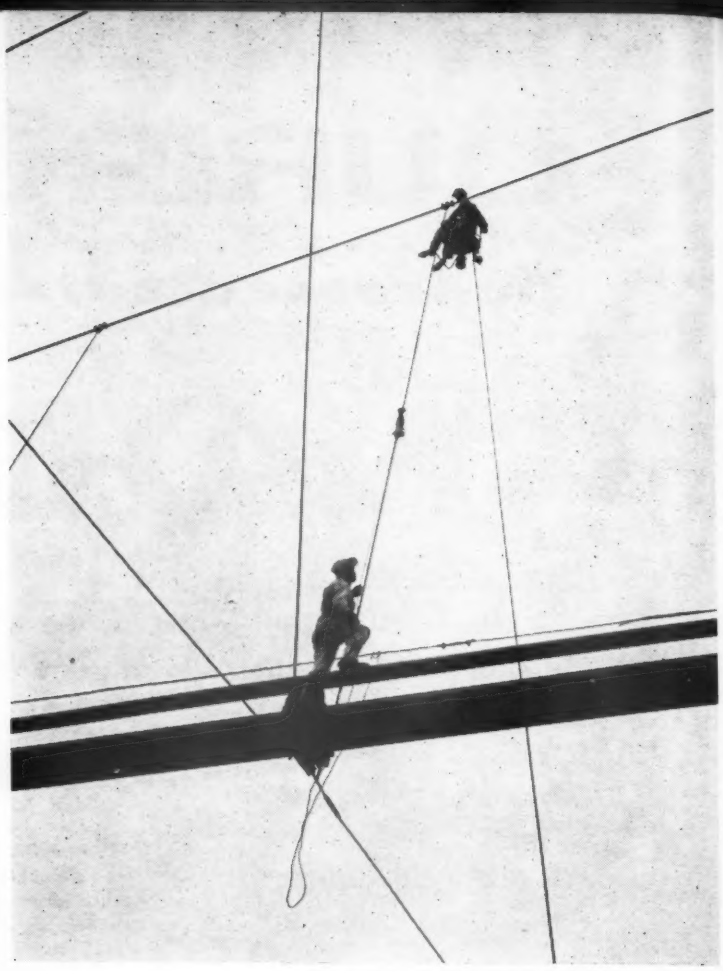
Bosun's Chair Makes Bridge Maintenance Easier Task

Lone Star Gas Company crews design and build their own special equipment for task of painting suspension spans



▲ Aloft, painter in chair and one on pipe line below pull paint-filled sheepskin cone back and forth to paint guy rods. Painter in bosun's chair then proceeds along top cable, painting as he goes and is met at next guy rod for repeat paint job with man below.

P 625.

C. Thompson*

INSTALLATION of a 1000-ft pipe line suspension bridge over the Brazos river south of Waco, Texas, gave Lone Star Gas Company maintenance men their first taste of bridge painting, back in 1941.

One maintenance crew completed the first bridge assignment in 573 man-hours without a single accident. Since then, the crew has taken over the periodic painting of all five of the company's suspension bridges scattered over the sprawling, two-state transmission system. And between interim jobs of painting gasoline plant and compressor installations, 427 city gate stations, and maintaining 297 company cottages, they have devoted a total of 7595 man-hours to bridge painting, without so much as a scratched finger.

A major factor in this safety record is the specially designed bosun's chair used for transversing bridge cables and wind rods.

Although bosun's chairs are not new for tower and bridge painting, this one is different. It combines both comfort and safety, and was designed by a cautious paint foreman who trained his men well for that first bridge job back in 1941.

The paint foreman, Henry T. Pollard, is now structure maintenance foreman for Lone Star's greatly increased maintenance operations and his original chair has been changed in only a few minor details.

Pollard was familiar with the stirrup seat used by contract painters. Most of them used hooks that had to be released one-by-one in transversing the clamps at suspender rod intersections along the bridge cable. But a man might lose his balance while maneuvering past the clamp. Pollard had a green crew and he couldn't take any chances.

The first chair was the jump seat out of a truck, to which a welded frame was added. The frame of ¾-in. pipe included a hinged back utilizing the spring-back rest of the truck seat, and had sturdy arm and foot rests.

Originally, four 18-in. lengths of suspension chain were fastened to the four corners of the chair and converged with a steel center ring above the chair seat. This arrangement not only supported the chair and its occupant but also served as a safety device to prevent his falling out. The hinged back, through which the workman could enter the chair, was bolted behind him and the design thus afforded complete security and comfort plus freedom of movement while working aloft.

Supported by an 18-in. chain at-

*Lone Star Gas Company, Dallas, Texas.

EXCLUSIVE

tached to the center ring on the chair, the device used a hanging block that served as a trolley in traveling the bridge cables. By using a second block as a spare, the workman was able to transverse a cable clamp with complete safety. By simply attaching the second block beyond the clamp, and using a boomer to release the first one, a man could proceed down the cable without either delay or risk.

When a second chair was constructed by the paint crew, coffin jacks were substituted for chain booms in both chairs. The second chair was also designed with a continuous welded frame for the center support instead of four lengths of chain. Rigging includes ½-in. manila rope, which is carefully inspected for breaks and wear before each bridge job is begun. There is also a set of control ropes trailing the chair from ground level for lifting and lowering the chair by workmen below.

Usually, an experienced man handles the initial task of climbing a bridge tower to put the first snatch block into place, in preparing the chair for use on a new job.

Both chairs are taken to each bridge job although only one is used. In case of emergencies the second chair can be dispatched to relieve the first man, by using the same set of ropes to pull the second chair aloft. In over 13 years, such an emergency has never occurred.

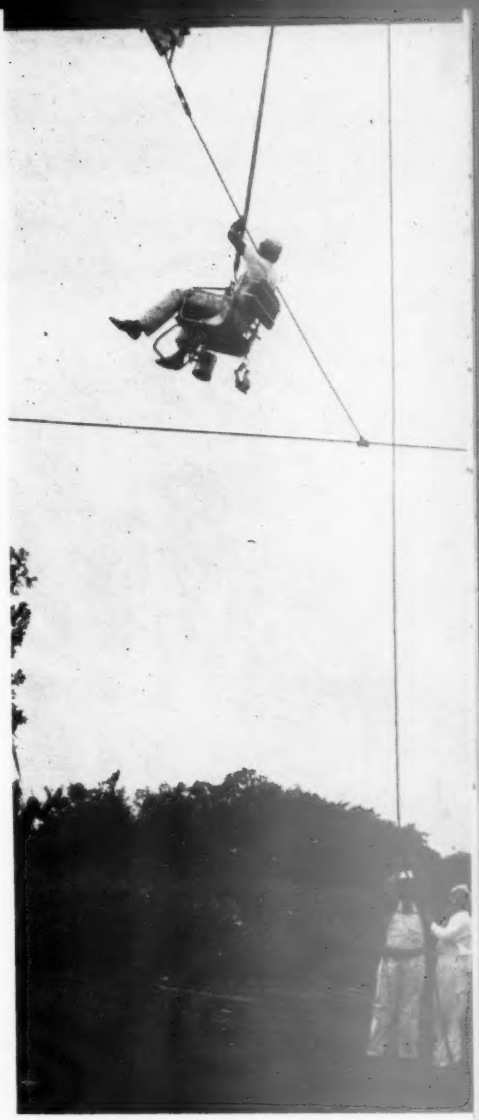
In painting 14,000 ft of suspension bridges ranging from 1030 to 2522 ft per span, the men have maintained 19 towers, each 75 ft high, and 500 suspender and wind rods averaging 6 to 40 ft in length.

Sheepskin, tied in funnel shape, is used for rod painting and is controlled from two points, one by ropes attached from catwalk or ground level, and one from the chair. Filled with paint the funnel of sheepskin is pulled back and forth along each rod until saturation is attained.

Towers are spray-painted by means of an extension paint gun built in the Lone Star shops. The gun can be attached to additional sections extending it from 3 to 10 ft with ¼-in. trigger rods and ¼-in. tubing for paint and air lines.

Lone Star's bosun's chair can also be used in painting pipe lines attached under highway or railroad bridges by suspending the chair from a special pipe dolly using ball bearing rollers.

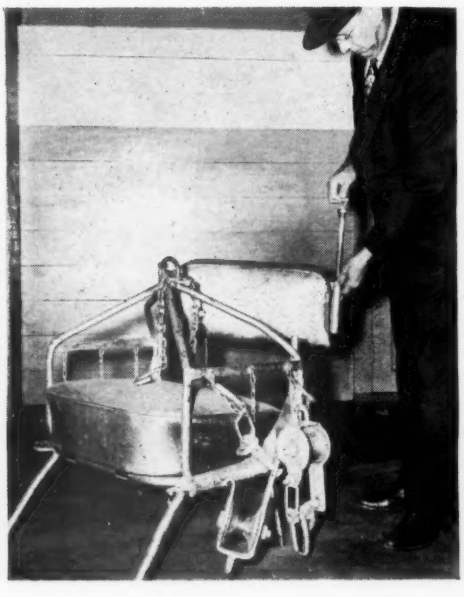
Each chair carries its own equipment such as paint buckets, wrenches, and other tools. And every bridge job handled by the paint crew includes a thorough inspection of bolts and connections that are secured as the work progresses. * * *



Bosun's chair and occupant are pulled aloft by workmen on the ground. Chain links and hooks on side of chair hold paint buckets, wrenches, and other tools needed in bridge maintenance.

▼ Henry T. Pollard shows snatching block used in transversing bridge cables with painter's bosun's chair. Chair has rear "stifflegs" because it appeared on television recently. Ordinarily, it is held upright while painter enters from back, by chain hoist.

▼ Chair is entered from the back, which swings out to admit occupant, and is then bolted into place behind him. Two snatch blocks are carried so one may be used to transverse a cable clamp as second one is released. The two blocks provide safety and speed in work aloft.



▼ View of chair, rigged for the picture to a shop beam, shows close up of chair's center support and arm, back and foot rests. Man could faint aloft and not fall out but has freedom of movement for his work. Seat and back are from truck cab, frame is ¾-in. pipe.

XUM

IN THE GOOD OLDE DAYS . . .

WHEN PIPELINERS FOUGHT FIRE

with (cannon) fire . . .

THE BRASH YOUNG MAN COMMANDED "Stand back!" He might be new at pipelining, but he was a graduate of West Point and he certainly ought to know more about firing a cannon than a bunch of numbskull pipeliners. The pipeliners stepped back and let him have at it.

Carefully, the West Pointer drew a bead on his target, a blazing tank of crude oil, and pulled the lanyard. The old Civil War cannon roared and belched a cloud of black smoke.

The West Pointer struck a Napoleonic pose and waited for the smoke to clear so that unschooled pipeliners could behold his markmanship. It finally cleared and his chest fell like a punctured ballon. His shot had sailed merrily over the blazing tank and punctured a perfectly good tank just beyond.

Old-timers admit that some pipelining wag probably made up the story about the West Pointer, but fighting fires with cannons is certainly not a bit of fiction.

Until about 1916—and in some cases up to the mid-1920's—cannons were standard fire-fighting equipment around tank-farms

Years ago, crude oil tanks had wooden roofs and leaked vapors. During electrical storms, the tanks were often ignited by lightning, and the crude oil inside was set ablaze. The longer the crude burned, the more it

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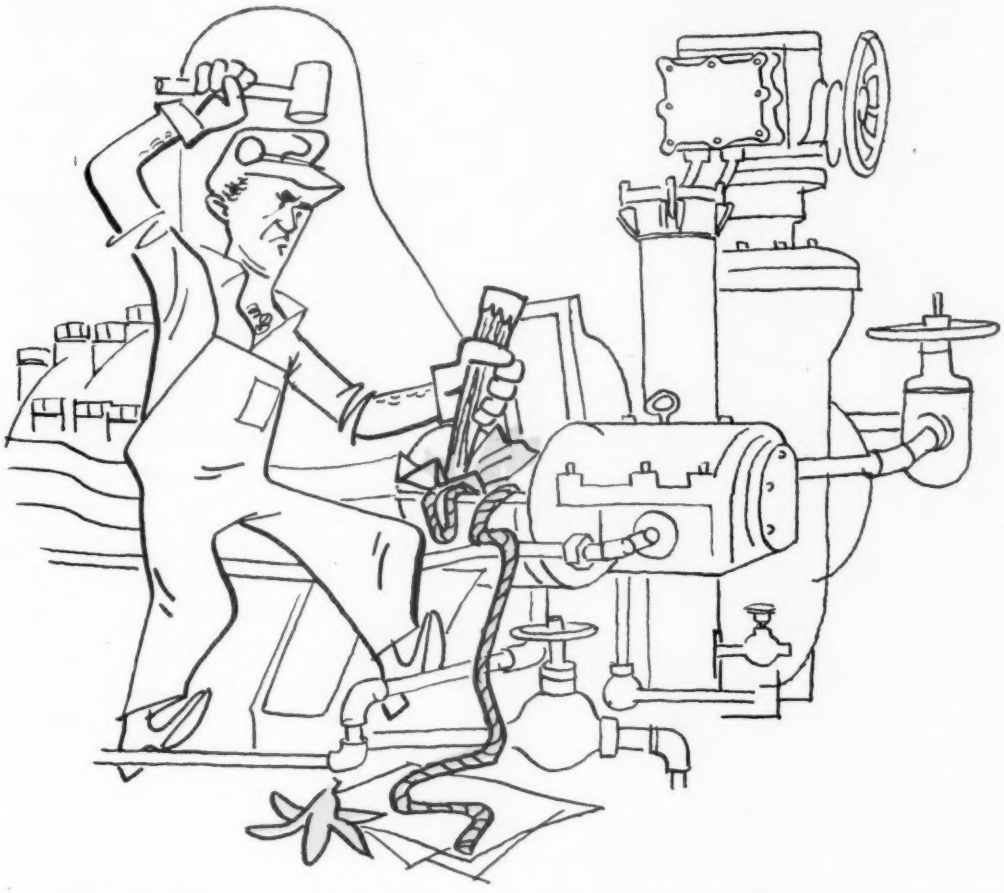

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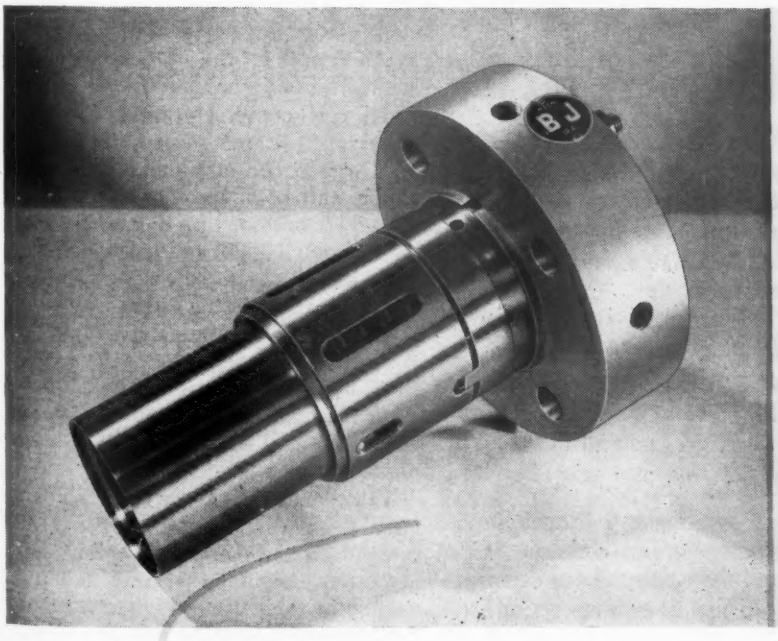

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heated the water that is found to a certain extent in any crude.

If the oil burned as much as eight hours, the hazards grew worse as the water would be steaming, and usually the tank would either boil over or explode, scattering flames to other tanks.

The purpose of the cannon was to pierce the tank and let the oil run out within the fire wall. That way the crude was spread out over a large area and the tank didn't have a chance to blow up and spread fire to other tanks.

Most of the cannons used for this purpose were Civil War models, similar to those seen in city parks. They were mounted on two large wheels and have a smooth, 4-in. bore.

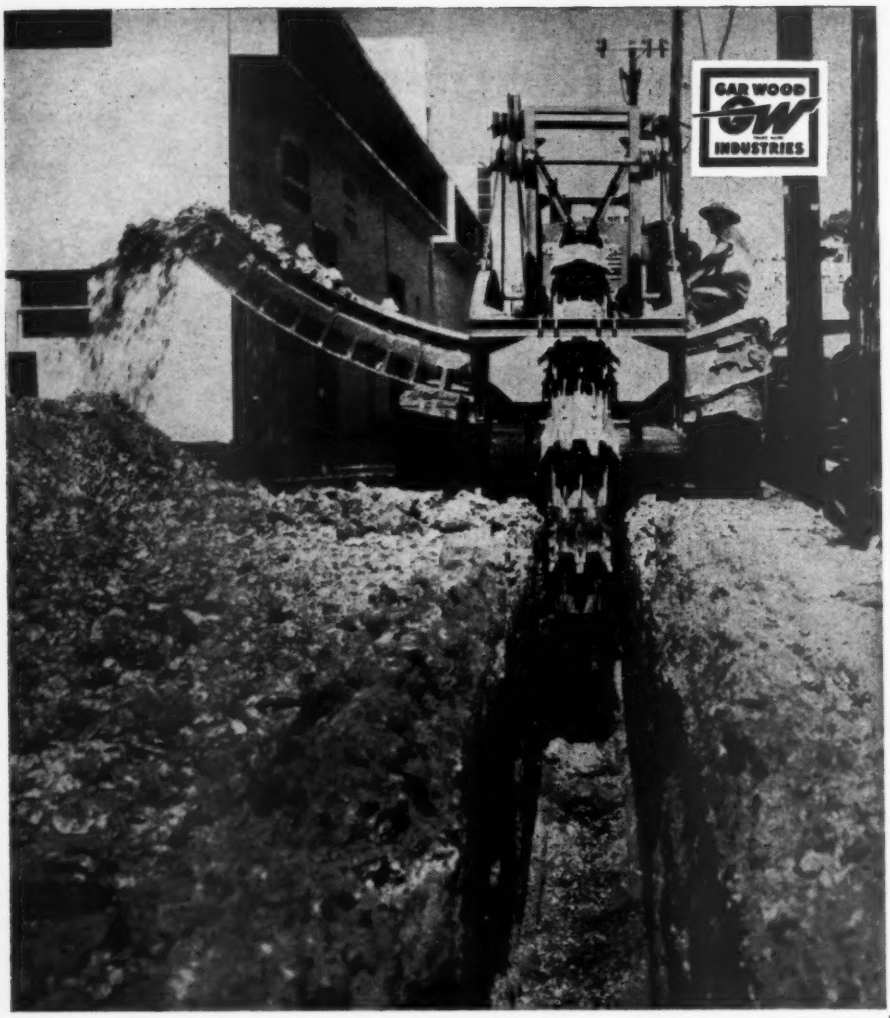
The cannons fired a cast-iron ball, propelled by a sack of black gun powder. Oil companies bought coarse-grained powder in bulk, then packed it two pounds to a bag. In loading the cannon, the men rammed a sack of powder down the barrel and followed it with a burlap wad, a cannon ball, and another burlap wad. They fired the cannon by a quick pull of the lanyard, which ignited a primer placed in the vent.

Sometimes they rammed too large a powder charge down the barrel. In one known instance, the pipeliners loaded their cannon, aimed, and fired. They hit the tank all right, but their charge was so large that the ball blasted all the way through the burning tank and into a second tank.

Companies generally stored cannons, powder, and other fire-fighting equipment in a shed near the tanks. Mules or horses were used to pull the cannons to the blazing tank. The cannoneers, who generally were connection crewment, station engineers, or anybody else available, set up the cannon about 30 to 50 ft outside the tank dike.

To get enough elevation, the cannoneers sometimes placed the cannon on a wagon bed and anchored it with chains and boomers. They aimed for the tank's bottom ring, but because of the cannon's kick and poor sighting (you aimed simply by sighting along the top of the barrel) they often hit higher, or shot completely over the tank. It was customary to circle a tank, shooting 15 to 20 holes in its shell. With two men on the cannon, it could be loaded and fired about every two minutes.

Tanks with steel roofs (and much later, those with floating roofs and fire screen ventilators) played a big part in cutting down the number and frequency of tank fires. With fewer tank fires to fight, the need for cannons grew much less. Some have been preserved as museum pieces, most junked or given away. * * *



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Recently added to the Buckeye line, the new model 315 is a wheel-type machine designed for the pipeline and utility field. Like every machine in the line, from the famous model "51" to the smallest, the "315" is built to stand up under the toughest usage and earn increased profits for its owner.

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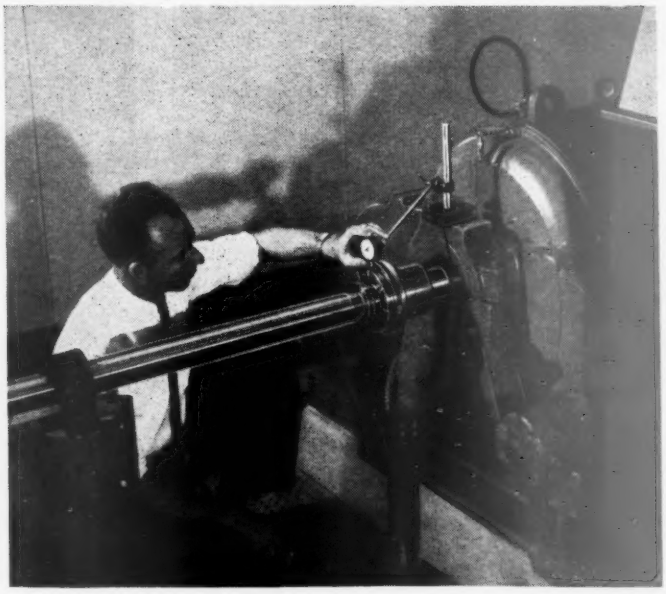

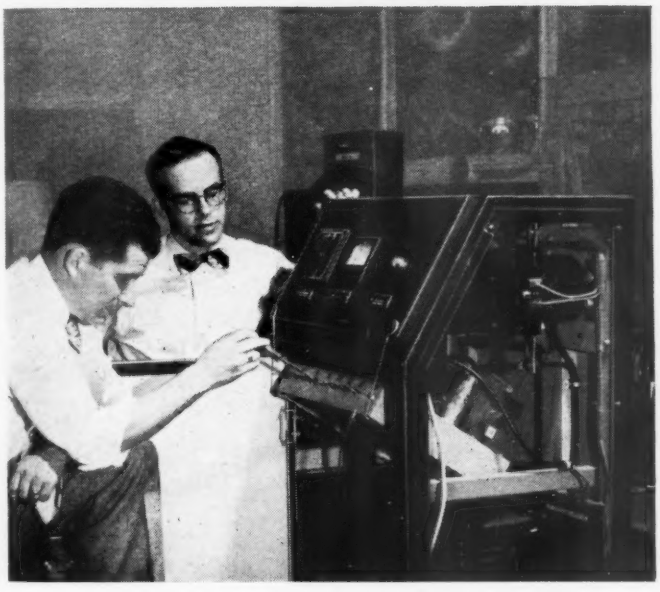

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One of the laboratory's primary functions is to design, produce and test new developments in piston rings and metallic sealing rings. This extensive program includes every phase of study from complete metallurgical research to actual engine testing for endurance and operating characteristics. Now and in the future, Koppers American Hammered Industrial Piston Rings will continue to mean *better* piston rings—engineered to give you *better performance.*

The new Koppers Mechanical Development Laboratory will benefit all industry. To put these benefits to work directly for you, consult Koppers whenever you have any problem in piston or sealing rings.

New lab studies all Koppers products

Research and testing under way in the new Koppers Development Laboratory includes: Endurance and operating tests for couplings, engine tests for piston and sealing ring endurance and characteristics, new precipitator controls and electrical equipment, pilot-plant tests of gas flow and distribution . . . and many more developments that will keep *all* products of Koppers Metal Products Division the most advanced in their field.

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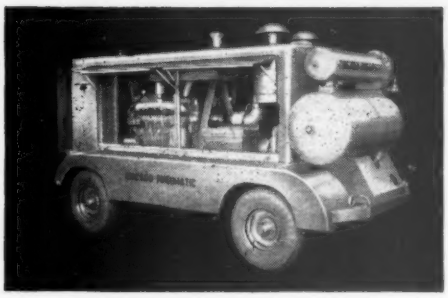

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pipe line personals

H. H. Kuester has been appointed a director and elected vice president of Pasotex Pipe Line Company. He has been manager of the land lease division of Standard Oil Company of Texas in Houston for the past nine years, and has been associated with the company since 1927.

Edward J. Mahoney, Jr., has been elected a vice president of Bechtel International Corporation, where he will function as special assistant to **S. D. Bechtel, Jr.** He will headquarter in San Francisco. Mahoney has closed his own pipe line construction firm, Mahoney Contracting Company of Lansing, Michigan, which he had operated the past eight years..

Joe D. Reid has been elected president and general manager of West Ohio Gas Company, Lima, Ohio. He succeeded **George S. Vail,** who has retired. Reid, who was vice president and operating manager, joined the company in 1946 following discharge from the Army Corps of Engineers. Before World War II, he was with Southern Union Gas Company at Dallas, Texas. He is a graduate of Southern Methodist University.

Joe D. Reid

F. E. Kalbaugh

Frank E. Kalbaugh has been named general manager of the newly-formed Southern Pacific Pipe Lines, Inc. He was formerly superintendent of the railroad's Salt Lake division. Kalbaugh joined SP in 1919 and advanced through operating department positions at various locations on the firm's lines. He will headquarter in the Pacific Electric Building, Los Angeles, California.

P. F. Clark has been named Pan American's safety supervisor. He was formerly senior deliveryman at Texas City. **E. R. Madding,** chief station engineer at Douglass, will succeed Clark as senior deliveryman. **J. D. Parkerson** succeeded Madding at Douglass. He was formerly engineer at Sabine.

James E. Allison has been appointed director of sales and customer relations for Texas Gas Transmission Corporation, Owensboro, Kentucky. He succeeded **Herman G. Horstman,** who has resigned to become vice president of Indiana Gas and Water Company, Indianapolis. Allison was formerly assistant director of the department he now heads.

Howard T. Scranton, assistant to Transcontinental Gas Pipe Line Corporation's vice president, eastern division, has transferred from Newark, New Jersey, to Decatur, Georgia, where he will continue in that capacity and be in charge of customer contacts in the southern sales area for the transmission firm.

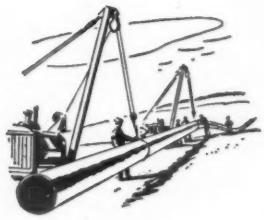
R. G. Rice, executive vice president of Tennessee Gas Transmission Company, has resigned to enter business for himself. He will remain as board chairman of Tennessee Life Insurance Company, a TGT subsidiary.

L. R. Dickinson

J. E. Allison

L. R. Dickinson has been appointed president of Trans-Northern Pipe Line Company, Toronto, Canada. He joined Trans-Northern in 1953 as vice president and general manager.

There Is No Secret To Pipelining



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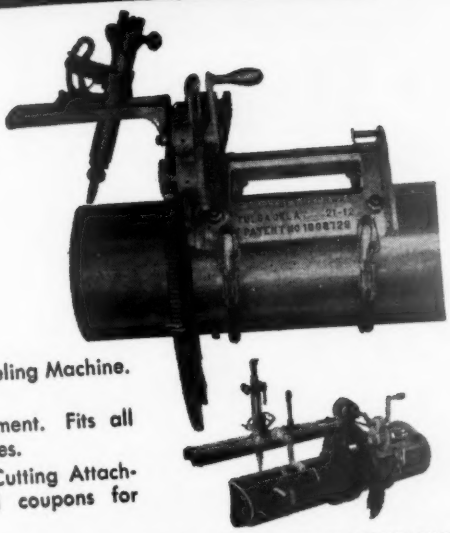

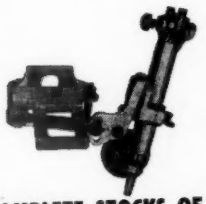

Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

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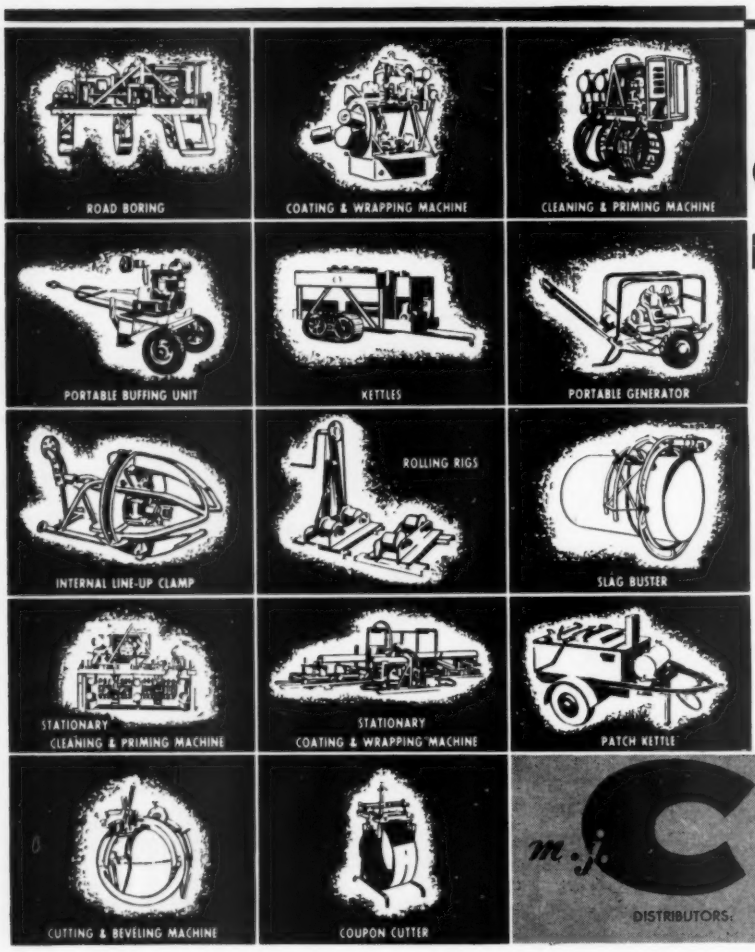
General Pipe Line Construction

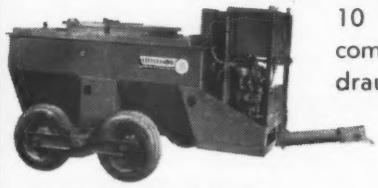


At home on the highway or tough pipeline terrain!

CROSE-LITTLEFORD

MODEL 211-10 P2

PIPE LINE KETTLE



For transporting on highway.

For tough pipeline terrain.

10 barrel capacity, complete with hydraulically operated agitator and low pressure burner, self-starting air cooled gasoline power unit. Mounted on tandem rocker beam assembly. Equipped with pneumatic tires and detachable (tire) tracks.

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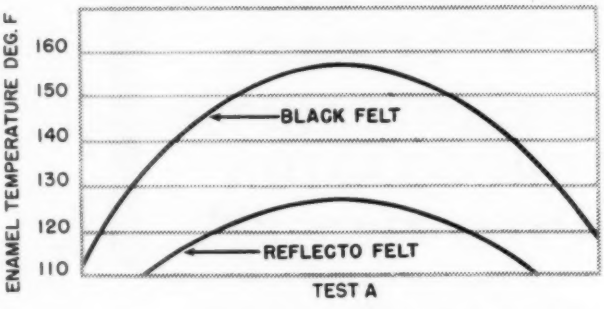
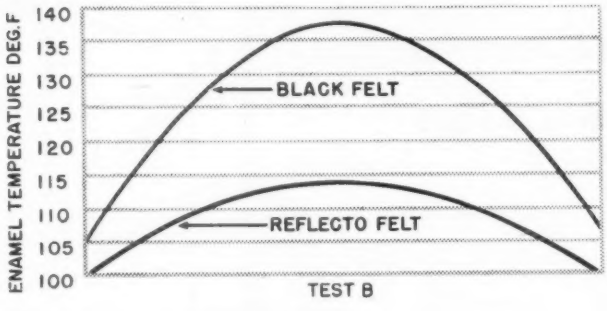
REDUCE TEMPERATURE

of ENAMEL as much as 30° WITH NICOLET REFLECTO-FELT





Above are the results of studies by an independent research organization upon the heat absorption characteristics of Nicolet Reflecto-Felt (white) vs. black felt.

Under controlled surface heat of 140 degrees, enamel under black felt registered 156 degrees. The enamel under Reflecto-Felt registered 126 degrees . . . A TEMPERATURE REDUCTION of 30 DEGREES.

With controlled surface temperature of TEST A reduced 30%, ENAMEL UNDER REFLECTO-FELT REGISTERED 23 DEGREES LESS THAN ENAMEL UNDER BLACK FELT.

WITH REFLECTO-FELT, YARD WRAPPED PIPE CAN NOW BE STORED.
ENAMEL SAG IS REDUCED ON PIPE COATED OVER THE DITCH.
INVESTIGATE REFLECTO-FELT NOW. *WRITE FOR LITERATURE.*

The Felt With a Future

MANUFACTURED BY:
NICOLET INDUSTRIES, INC.

70 PINE STREET
NEW YORK 5, N. Y.

R. J. Andress

T. R. Aude

R. P. Lennart

S. N. Williams

R. J. Andress has been elected executive vice president of Service Pipe Line Company. He formerly was vice president in charge of traffic. Andress joined Service in 1946 and was elected to its board of directors in 1948. He is a lawyer and an authority on pipe line traffic.

T. R. Aude, director and former manager of planning and economics for Service, was elected to succeed Andress. Aude, an engineer, joined the company in 1930 and was elected to its board in 1948.

R. P. Lennart has been appointed manager of planning and economics, replacing Aude, and **S. N. Williams** has been named supervisor of oil movements, succeeding Lennart. Lennart, a graduate of Marquette University, assisted in the design and operation of all pump stations on the emergency "Big Inch" and "Little Inch" pipe lines. He joined Service as a mechanical engineer in 1946. In 1947, he was promoted to senior engineer and became executive assistant to the general manager.

Williams joined the company in 1930 and was named assistant supervisor of oil movements in 1950.

John Holder has been promoted to superintendent of Service Pipe Line's telephone and telegraph section. He succeeded **F. P. (Pat) O'Connor,** who has retired after serving the company's communications branch for over 35 years. Holder joined the company in 1919 as a telegrapher. He has been assistant superintendent of the telephone and telegraph section since 1931.

H. G. Mariner has been appointed assistant to the general manager and **H. T. Chilton, Jr.,** has been named maintenance superintendent for Service. Mariner, former maintenance superintendent, joined the company in 1940 as a draftsman and instrument man. He was previously an engineer with Lago Petroleum Corporation in Venezuela and held positions with Interstate Pipe Line Company and Phillips Petroleum Company. Chilton, who recently returned from serving as a consultant on the U. S. Army products pipe line being built across France, joined Service in 1947 as a junior engineer. He was promoted to executive assistant in 1954.

John Holder

John F. Barth

H. T. Chilton, Jr.

John F. Barth has been named assistant supervisor of Service's authorizations department. He joined the company in 1933, was named senior clerk in 1941, and administrative assistant in 1946.

Lowell E. Anderson has been named division chief engineer for Service's Wyoming division, where he will assist **R. R. Strand,** Wyoming division manager. He is a native of Nebraska and a civil engineering graduate of the University of Nebraska. He joined Service in 1947.

John C. Jacobs, Jr.

A. J. Helmbrecht

John Clayton Jacobs, Jr., has been elected a vice president of Texas Eastern Transmission Corporation. He has been executive vice president and a director of Wilcox Trend Gathering System, Inc., a subsidiary, and will continue to operate in those capacities. He is an attorney and a graduate engineer.

W. M. Stephens has been appointed acting superintendent of construction for Texas Eastern. An engineer with the company since 1950, he will supervise the activities of the communications, compressor station, electrical, materials, and pipe line sections of the company's engineering department. A professional engineer since 1927, he is a graduate of Texas A&M.

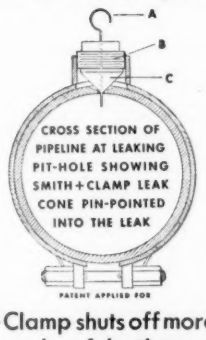
A. J. Helmbrecht has been elected vice president of Buckeye Pipe Line Company. A graduate of Stevens Institute of Technology, he joined Buckeye in 1935 as assistant ot the chief engineer. In 1948, he was promoted to chief engineer, and in 1952 was named assistant to the president.

John R. Hussey has been named manager of transmission lines for United Fuel Gas Company. He succeeded **Vernon E. Frazier,** who has left the company after almost 25 years' service to enter private contracting business in the Charleston, West Virginia, area. Hussey has been with United Fuel Gas since 1926. Since 1954, he has been assistant manager in charge of all production fields.

Andrew J. Sledge has retired from service with Pan American Pipe Line Company at Alvin, Texas, after 31 years. For the past 14 years, Sledge was in charge of Pan American's main line station at Alvin. He began pipelining in 1924 with Stanolind Pipe Line Company, tranferring to Pan American in 1940.

F. C. Whiteside, for the past five years an executive of Continental Pipe Line Company, Ponca City, Oklahoma, has been appointed manager of pipe line operations and crude oil sales for Hudson's Bay Oil and Gas Company with headquarters in Calgary, Alberta. Both companies are affiliates of Continental Oil Company.

Smith + Clamp Permits Plugging and Welding Pit-Hole Leaks in a Pipeline While Pumping Through It.


A
B
C
CROSS SECTION OF PIPELINE AT LEAKING PIT-HOLE SHOWING SMITH + CLAMP LEAK CONE PIN-POINTED INTO THE LEAK
PATENT APPLIED FOR

Smith + Clamp shuts off more easily, quickly and safely than ordinary clamps. Use on high and low pressure gas, gasoline, crude oil, water, steam, air, chemical process and other pipelines. Sizes 1″ to 30″. Combine with WELDPLATE when pipe reinforcement is specified.

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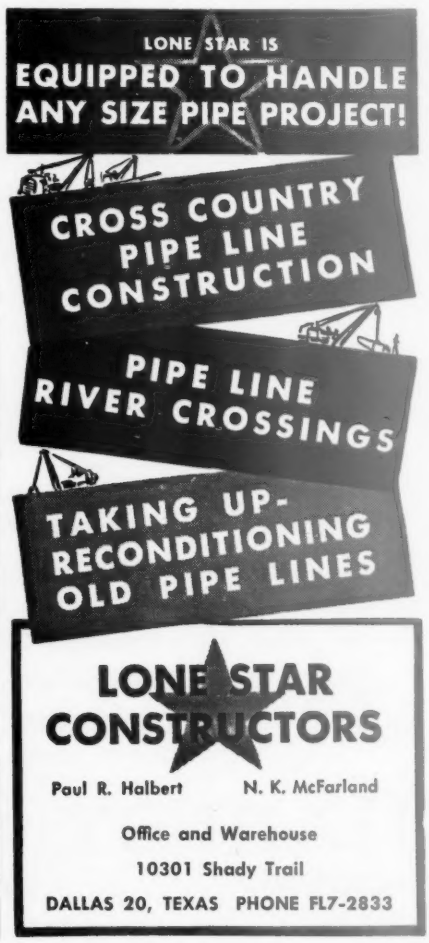
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Personals

Charles M. Stone has been named assistant chief engineer for Colorado Interstate Gas Company. A graduate of the University of Colorado, he was with The Texas Company for seven years and Stearns-Roger Manufacturing Company for six years, prior to joining Colorado Interstate in 1954.

Grove Lawrence, vice president of Southern California Gas Company, has been selected to serve as second vice chairman of the AGA operating section, succeeding **F. A. Hough,** Bechtel Corporation, who resigned because of a change in company affiliation.

W. J. Williamson has been elected director and appointed corporate secretary of Shell Pipe Line Company, succeeding **A. E. Groff,** retired. The company has also announced the retirement of **F. W. Littell,** manager of the firm's communications and transport facilities. Littell will continue to serve as a consultant on communications problems. **J. W. LaBoon** has been named to succeed Littell as manager of the communications department.

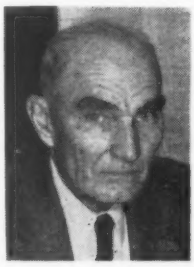
J. D. McConnell, Sinclair Pipe Line Company, Independence, Kansas, has been elected a member of the board of Platte Pipe Line Company, succeeding **H. L. Phillips,** Sinclair Oil Corporation, New York City.

F. G. White has been promoted to assistant division superintendent of Magnolia Pipe Line Company's northern division at Oklahoma City, Oklahoma. He was formerly district superintendent at Brownfield, Texas. **A. W. Butler,** who has been assistant district superintendent at Brownfield, will succeed White as the North Basin district superintendent.

H. W. Branum, engineer with Continental Pipe Line Company's North Texas district since 1950, has been named superintendent of Pioneer Pipe Line Company with headquarters at Salt Lake City, Utah.

D. M. McBride has been promoted to manager, Phillips Petroleum Company's supply and transportation department. Other promotions include **John E. Harris** to succeed McBride as manager of crude oil purchases and sales, and **G. J. Derrick** as general traffic manager, replacing **S. P. Nunley,** deceased.

H. L. "Jack" Wheeler has been promoted to wire chief for Service Pipe Line Company. He succeeded **G. J. Frisinger,** who has retired under the company's annuity plan. Wheeler has been with Service since 1933, entering Service as an electrician and subsequently advanced to administrative assistant.



E. J. Tennyson

Lee May

Ed J. Tennyson, division superintendent for Pan American Pipe Line at Longview, Texas, has retired after 34 years service. He began his pipelining in 1921 with Stanolind and transferred to Pan American in 1940. **Lee May,** division foreman at Longview, succeeds Tennyson as division superintendent. May, a graduate of Rice Institute, has been with the company since 1941.

The appointment of two chief engineers for The Lincoln Electric Company has been announced by **L. K. Stringham,** engineering vice president.

Norman J. Hoenie has been appointed chief engineer, machine division; **Emmett Smith,** chief engineer, electrode division. Both men, prior to their appointment, have been assistant chief engineers of their respective divisions.

Hoenie joined the Lincoln engineering department following his graduation from the Ohio State University with an electrical engineering degree in 1931. As a development engineer for the department, he supervised many of the development projects for new welding machines that the company pioneered. One of the most significant of these was the first welding machine to provide control of both amperage and volts in the welding circuit giving dual-continuous control.

Smith graduated from the Ohio State University in 1928 as an electrical engineer and immediately joined the Lincoln engineering department. At that time, Lincoln was beginning to develop automatic welding machines, to which project Smith was assigned as a development engineer. He worked on both machines and fluxes for the carbon arc automatic process, known as the Electronic Tornado. From this project evolved the development of the Lincolnweld hidden arc process.

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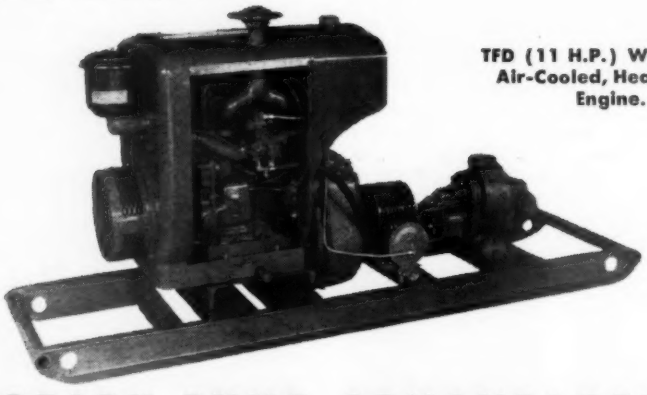
ARE BEST IN MANY APPLICATIONS

The speed-up pattern of modern machinery through advances of metallurgy has made ROTARY PUMPS universally accepted.



TFD (11 H.P.) WISCONSIN Air-Cooled, Heavy Duty Engine.

ROTARY PUMP ADVANTAGES:

- Less weight in lbs. in BPD capacity
- Greater portability • Lower cost
- High Self Priming Characteristics • Greater smoothness of operation • Elimination of pulsation in line which is often destructive to pipelines
- Much more easily serviced

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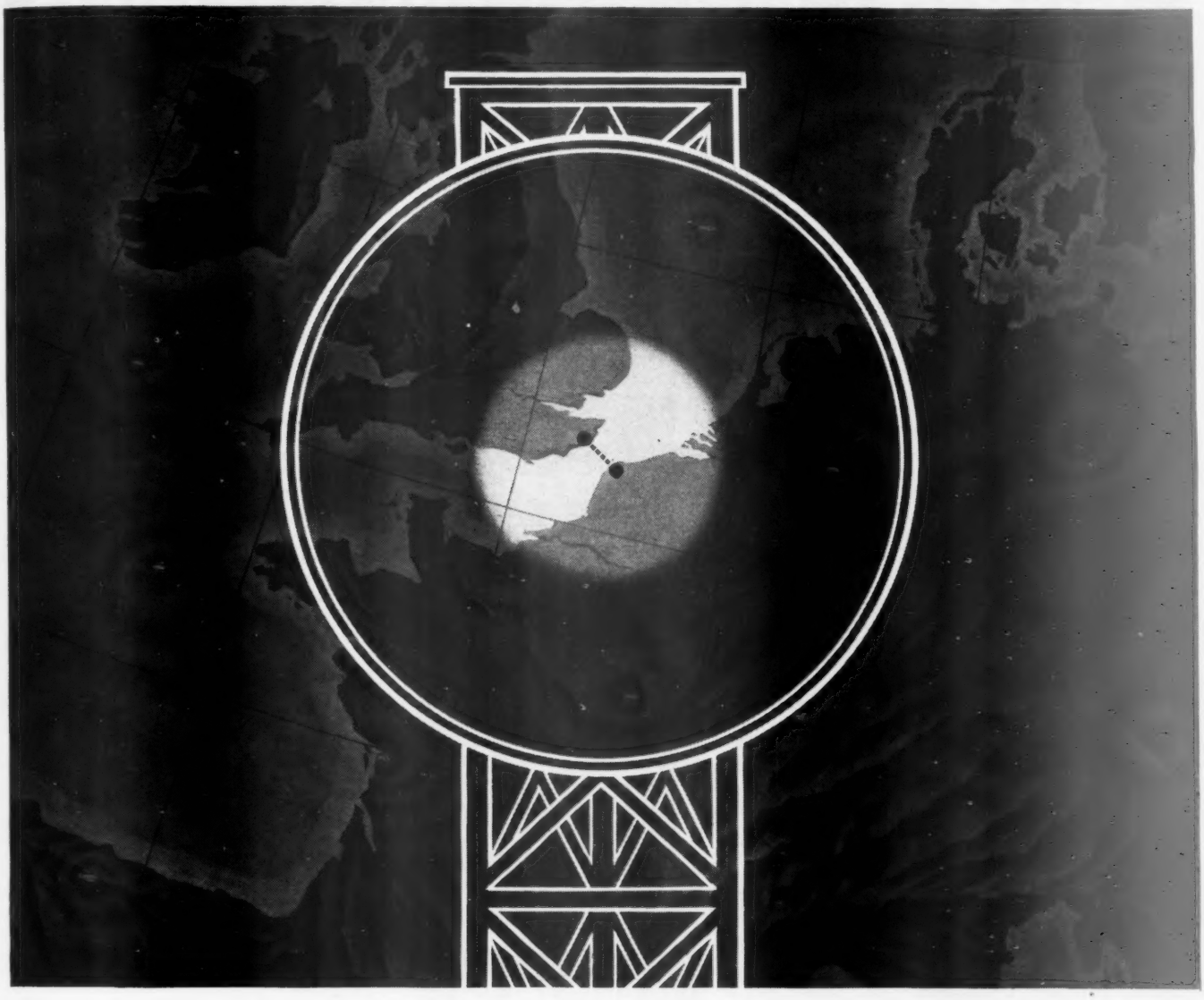

"Hello, Calais, this is Dover calling!"

Nearly a quarter of a century ago the world's *first* public demonstration of microwave communication took place across the English Channel, when scientists of International Telephone and Telegraph Corporation established telephone and teleprinter service between Calais, France, and Dover, England.

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WITH THE PIPE LINE CONTRACTORS

● **Panama-Williams Company, Melrose Building, Houston, Texas.** Has 36 miles of 30-in. and 31.4 miles of 36-in. in South Carolina and North Carolina for *Transcontinental Gas Pipe Line Corporation*. W. H. Shiflett, superintendent; Lloyd Evans, assistant superintendent; Hank Scherer, office manager.

● **Williams-Austin Company, Grant Building, Pittsburgh 19, Pennsylvania.** Has 31 miles of 26-in. loop gas lines in West Virginia for *Atlantic Seaboard Corporation*. Warehouse at Buckhannon, West Virginia; Ed Peters, general superintendent, Ralph Gaddy, spread superintendent.

● **O. R. Burden Construction Corporation, 6702 East 21st, Tulsa, Oklahoma.** Has 31 miles of 30 and 36-in. in Louisiana for *Transcontinental Gas Pipe Line Corporation*. Also has 120 miles of 12 and 14-in. between Midland and Corsicana, Texas, on looping project for *Magnolia Pipe Line Company*. Bob Jones, superintendent.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 65 miles of 12-in. products line for *Shell Pipe Line Corporation*, Baton Rouge to Norco Refinery (New Orleans), Louisiana. Job resumed and underway after delay due to right-of-way acquisition. Also has 84.8 miles of 36-in. (with H. C. Price Company) in Alabama and Georgia for *Transcontinental Gas Pipe Line Corporation*. Also has 14 miles of 20-in. for *Texas Gas Transmission Corporation* near Minden, Louisiana.

● **R. H. Fulton & Company, Box 1526, Lubbock, Texas.** Has 55 miles of 30-in. steel water line for *City of Colorado Springs, Colorado*.

● **H. L. Gentry Construction Company, Box 32, Perrysburg, Ohio.** Has 18 miles of 20-in. in West Virginia for *United Fuel Gas Company*.

● **H. B. Zachry Company, Box 2570, San Antonio, Texas.** Has 90 miles of 12 and 16-in. loops for *Magnolia Pipe Line Company*, eastern section of the firm's Midland-Corsicana system. A. "Pup" Vaughan, general superintendent.

● **Texas Engineering and Construction Company, Amarillo, Texas.** (Formerly Z. Jack Graham Company). Has 40 miles of 4 and 6-in. gas line for *Pioneer Natural Gas Company*, near Plainview, Texas.

● **B&M Construction Corporation, Oklahoma City, Oklahoma.** Has contract for construction of 500 miles of 12-in. products line from Cadiz to Zaragoza, Spain, for *U. S. Navy* as part of joint venture. A. C. Montin, project manager, in care of Hilton Hotel, Madrid, Spain. Job to start June 1, 1955.

● **Mannix, Ltd., 332 7th Avenue West, Calgary, Alberta, Canada.** Has 100 miles of 3 through 10-in. gathering system for *Pembina Pipe Line Company*. George Hupp, manager; field office at Drayton, Valley, Alberta.

● **Modern Welding Company, Box 528, Owensboro, Kentucky.** Has 112 miles of 6 through ¾-in. for *Southeast Alabama Gas Corporation* in cities of Seale, Newville, Abbeville, Headland, and Eufaula, Alabama; 55 miles of 6 through ¾-in. for *City of Flora, Illinois;* 25 miles of 12 through ¾-in. for *Gas Light Company* of Columbus, Georgia; and 12 miles of 6 through ¾-in. for *Alabama Gas Corporation* in Gadsden, Alabama.

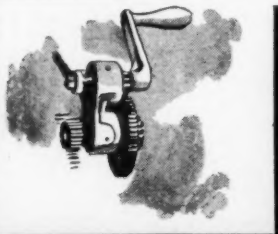
● **Oklahoma Pipe Line Constructors, 6612 Harry Hines Boulevard, Box 13227, Dallas, Texas.** Has 115 miles of 24-in. between Mansfield and Lackawaxen, Pennsylvania, for *Tennessee Gas Transmission Company*. N. L. "Cajun" Arie and Guy Craft, superintendents at Honesdale and Troy, Pennsylvania.

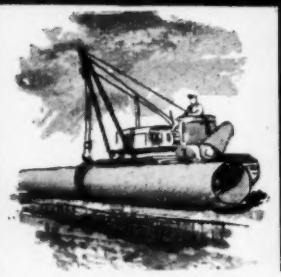
● **Williams Brothers, National Bank of Tulsa Building, Tulsa, Oklahoma.** Has 160 miles of 6-in. for *Bolivian government*, oil line. Has 115 miles of 30-in. between Toledo and Cleveland, Ohio, for *East Ohio Gas Company*. Has 72 miles of 30-in. in Virginia for *Transcontinental Gas Pipe Line Corporation*.

● **Engineers Limited Pipe Line Company, 225 Bush Street, San Francisco, California.** Has 37 miles of 16 and 20-in. in Washington for *Trans Mountain Oil Pipe Line Company*.

a precision instrument

H & M Pipe Cutting and Beveling Machines are designed and manufactured to high engineering standards. Close tolerances in gear design consistently give cleaner, more accurate cuts, yet the H & M is rugged and will withstand years of tough field use.





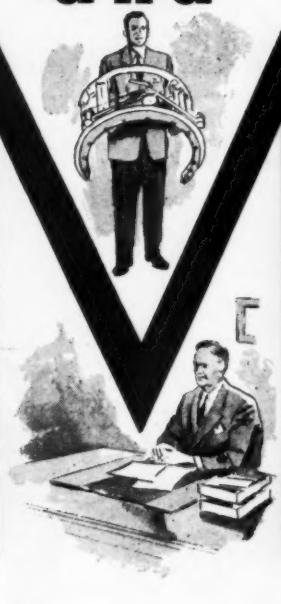
for pipe cutting and beveling

A complete line of beveling machines is available from H & M. The #1 machine will cut and bevel pipe as small as 4", the #5 machine will handle a diameter of 36". Once in place the entire 360° cut can be made in a matter of minutes with an effortless turn of the hand crank.

and

now lightest in its class

A new metal manufacturing process has recently made the H & M the lightest beveler in its class . . . has actually reduced the weights of the number 3, 4, and 5 machines by 40%. Think of what this means in the field—new lightness without any loss of durability.



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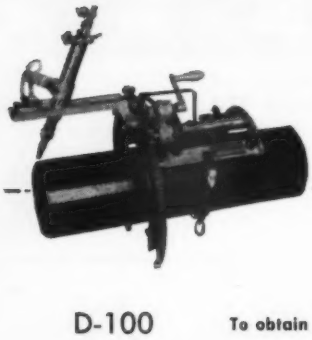
Point for point the H & M gives you more. It is actually possible to save one-half your labor and gas cost by using the H & M Pipe Cutting and Beveling Machine. Attachments are available for out-of-round and shape cutting. For more information, write H & M.



H&M PIPE BEVELING MACHINE COMPANY

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Contractors

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 35 miles of 26-in. loops in Ohio and Pennsylvania for *Tennessee Gas Transmission Company*. Also has for *TGT* approximately 18 miles of 24-in. connecting Harrison and Hebron Storage fields and 50 miles of mainline, 24-in. Also has 77 miles of 26-in. in western Kentucky and Tennessee in six main line loops, plus 72 miles of 12-in., 37 miles of 10-in. and 5 miles of 8-in. in Indiana, for *Texas Gas Transmission Corporation*.

● **O. R. Burden Construction Corporation, 6702 East 21st, Tulsa, Oklahoma.** Has 50 miles of 8-in. products line between Cushing and Tulsa, Oklahoma, for *Texaco-Cities Service Pipe Line*. Has 31 miles of 30 and 36-in. in Louisiana for *Transcontinental Gas Pipe Line Corporation*.

● **Jess Whitlaw, Ponca City, Oklahoma.** Has 70 miles of 3 through 16-in. gathering system for *Pure Oil Company* in vicinity of Adena field, northeast Colorado.

● **Hallmac Construction Company, 2261 West Holcombe, Houston, Texas.** Has approximately 100 miles of 10-in. for *South Georgia Natural Gas Company*.

● **Buchanan Pipe Line Construction Company, Birmingham, Alabama.** Has 80 miles of 6 and 8-in. for *South Georgia Natural Gas Company*.

● **Cumberland Contracting Company, Monticello, Kentucky.** Has approximately 225 miles of 2 through 10-in. for *Southeast Alabama Gas District*.

● **Mid States Construction Company, Box 417, Mt. Vernon, Illinois.** Has 110 miles of 2 through 12-in. for *South Georgia Natural Gas Company*.

● **Associated Pipe Line Contractors, Box 13216, Houston, Texas.** Has 63.5 miles of 36-in in Louisiana and Mississippi and 71 miles of 30-in. in Virginia and Maryland for *Transcontinental Gas Pipe Line Corporation*.

● **Midwestern Constructors, Inc., 402 North Boulder, Tulsa, Oklahoma.** Has 14.5 miles of 30-in. and 53.5 miles of 36-in. in Alabama for *Transcontinental Gas Pipe Line Corporation*.

● **Western Constructors, Austin Texas.** Has 76.8 miles of 36-in. in Georgia and South Carolina for *Transcontinental Gas Pipe Line Corporation*.

● **Pipe Line Contracting and Drilling Company, P. O. Box 165, Lemoyne, Pennsylvania.** Has 46 miles of 26-in. in three loops in West Virginia and Maryland for *Atlantic Seaboard Gas Corporation*.

● **Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma.** Has 150 miles, 6 to 10-in. gas line for *Southeast Alabama Gas District*. Two spreads: Gene Coulter, superintendent at Eufaula, Alabama, and Jim Williams, superintendent, Headland, Alabama.

● **Merritt-Chapman & Scott Corporation, 260 Madison Avenue, New York 16, New York.** Has 53 miles of 8 to 24-in. between Bombay and Butcher Island for *Bombay Port Trust, India*. Also 16 miles of 16-in. between refinery and Sydney for *Australian Oil Refining*.

● **Foster-Wheeler Corporation, 165 Broadway, New York 6, New York.** Has overall supervision of a 1920-mile NATO pipe line system in Europe.

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AT ALL 7 PLS PLANTS

Where experience and the most modern facilities are combined to give you more for your money in cleaning, priming, coating and wrapping steel pipe.

PLS-Franklin Park is strategically located within the Chicago switching district, near Chicago, Indiana Harbor, and Gary tube mills and is served by the Chicago, Milwaukee, St. Paul and Pacific Railroad. Pipe can also be stopped off at Franklin Park for coating and wrapping and reshipment at through freight rates from eastern mills. 20 acres provide ample storage space for our customers' pipe. 93,000 square feet under roof assure prompt service at all times.

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...the Quality Coal Tar Coating

There is one dependable yardstick for measuring the quality of protective material: How does it stand up over years of service?

You don't have to experiment when you specify TAPECOAT. It is quality coal tar coating, and coal tar is nature's own defense against corrosion.

Since 1941, when it was introduced as the first protective coating in handy tape form, TAPECOAT has proved its ability to keep vulnerable steel surfaces in "like new" condition year after year. **That's why it is specified by those who know that continuing protection is the first consideration.**

For 14 years, TAPECOAT has provided dependable protection on pipe, pipe joints, tanks, etc., above ground and under ground.

TAPECOAT comes in handy rolls in widths from 2" to 24". It's easy to apply and the coal tar provides both bond and protection at the same time.

Write for brochure and recommendations on your corrosion problem.

The TAPECOAT Company

Originators of Coal Tar Tape Protection

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Pipe Line Projects

Albuquerque Terminal Planned by Texaco

A new pipe line terminal and bulk plant will be constructed by The Texas Company at Albuquerque, New Mexico. It will be supplied by a products pipe line from El Paso, Texas, operated by the Standard Pipe Line System. The terminal, with complete bulk plant facilities, will replace the existing bulk plant now supplied by rail and transport truck. Total storage of 90,000 bbl will be provided to receive motor gasolines and diesel fuel. The terminal site, consisting of 7 acres, has been acquired and construction is scheduled to be completed June 1.

Great Lakes Completes Kansas Products Line

Great Lakes Pipe Line Company has completed its 10-in. line from El Dorado, Kansas. The new direct route to Kansas City supplements an 8-in. line that links refineries at El Dorado and nearby locations to the Great Lakes system at Humboldt, Kansas, east of El Dorado.

A diesel-powered pumping unit at El Dorado will provide the 10-in. line with a capacity of 36,000 bbl per day. This volume can be increased to 46,000 bbl when necessary by use of an intermediate station at Topeka. The diesel-powered Topeka station will be operated by remote control from El Dorado.

Tennessee Gas Authorized 370-Mile Gulf Coast Line

Authorization to build a new 370-mile, 30-in. gas line from Kinder, Louisiana, to near Aqua Dulce, Texas, has been given Tennessee Gas Transmission Company by the Federal Power Commission. The $35,400,000 line will be built as a substitute for 211 miles of pipe line previously authorized by the commission but never constructed. The new line will give TGT mainline facilities where it now has only minor laterals.

Two Pipe Line Projects Planned by El Paso Natural

Preparation of applications to the FPC is underway by El Paso Natural Gas Company on two major projects that will boost the capacity of the system some 500,000,000 cu ft in the next three years. One application will seek permission to build a 370-mile line from a connection in southern Idaho on the Pacific Northwest Pipe Line to the California-Nevada border near Reno. This line is scheduled for 1958 completion. El Paso has agreed to purchase 250,000,000 cu ft daily from Pacific Northwest when its system is completed.

The company also will ask permission to increase deliveries from the San Juan Basin to California by 200,000,000 cu ft. Facilities to handle an additional 100,000,000 cu ft daily are planned for 1956 and facilities for another 100,000,000 cu ft additional capacity are planned for 1957.

Two-Mile Offshore Line in California

Work has begun on a buried 10,500-ft pipe line system connecting Monterey Oil and Texas Companies' offshore wells with a separation center immediately north of Second Street in Seal Beach, California. The pipe line system consists of a cluster of four lines and is being laid by Healy-Tibbitts Construction Company, builders of the offshore well site itself. The main line will be 8-in. and have a capacity of 10,000 bbl per day. The remaining three lines of the cluster will each be 3-in. pipe and will be used for fuel, water and mud delivery, and for various testing purposes. A multiple conductor armored cable is being laid at the same time to provide electric circuits for telephones and on-shore controls. Construction is scheduled for completion in 60 days.

Weld+Ends Permits Welding a Pipeline While Pumping Through It.

A pipeline safety welding coupling for crude oil, gas, gasoline, asphalt, steam, chemical process and other pipelines. WELD+ENDS joins pipe securely so flow can be resumed immediately at full pressure. Welding can be performed while pipeline is in use days or weeks later. Sizes 2" to 30".

Pipe Line Development Co.
5700 Detroit Avenue Cleveland 2, Ohio

Peace River Crude Line Contracted

The group of major companies with the largest production interest in the two Sturgeon Lake oil fields has been awarded a construction permit for a crude oil pipe line, through the operating medium of a new pipe line company named Peace River Oil Pipe Line Co. Ltd. The line will run for 106 miles from Sturgeon Lake to the pumping station at Edson on the Trans Mountain pipe line about 100 miles west of Edmonton. The owner companies named in the charter of incorporation are Amerada Petroleum Corporation; Canadian Gulf Oil Company; Hudson's Bay Oil and Gas Company, Ltd.; Imperial Oil, Ltd.; Shell Oil Company, and Union Oil Company of California. In awarding the permit, however, The Petroleum and Natural Gas Conservation Board of Alberta directed that provision should be made for admitting other companies with interests in the Sturgeon Lake and tributary areas to a share in the pipe line company.

Engineering plans call for a 16-in. line for the first portion of the line from Sturgeon Lake to Iosegun Lake, with a 12-in. line for the remainder of the distance to Edson. Decision to build directly to the Trans Mountain line rather than to Edmonton was dictated largely by cost factors. The line to Edson, with optimum capacity of 32,500 bbl per day, would require an average 10-year tariff of 9.6 cents per barrel, while a 12-in. line to Edmonton, a combined distance of 210 miles, would require 13 cents. Maximum capacity of the line to Edson will be 57,600 bbl per day.

Limiting distribution of its crude to the Trans Mountain line is of no practical significance to the producers, under the provincial prorationing system of production allowables, although it might have some impact on the operations of the line in a period of low markets in the area served by Trans Mountain. At such a time the traffic volume might have to be reduced below its mathematical share of the whole market, because there would be no way to send any flow upstream into the Trans Mountain line back to Edmonton. Conversely, in a flush market period, the Sturgeon Lake field would still be limited to its pro rata share of total production, so that a rise in the Coast market would be filled partly from other Alberta production and not entirely from crude moved by the Peace River line.

Construction is scheduled to be commenced after the spring thaw and to be completed this year. No date has been stated yet for calling of tenders or award of contract.

New X-Ray Inspection Firm Organized in Houston

A new firm, Pipeline X-Ray Service of Texas, has been formed to assume the pipe line X-ray weld services formerly offered by Richardson X-Ray Service of Alhambra, California. The new company will headquarter at 1076 M&M Building in Houston, Texas. C. W. Radcliff, vice president in charge of Richardson Pipeline Service, will be general manager of the new firm.

Personnel and equipment will remain the same. Pipeline X-Ray will continue to offer the same services in all areas except California, which has been retained by Richardson under the purchase agreement.

The new firm's first job will be inspection of approximately 600 miles of pipe line being built in Spain.

Gas Sales Increase During 1954, Says AGA

Total gas sales to ultimate consumers reached a new high in 1954, the American Gas Association reports. An increase of 8.4 per cent over 1953, on the basis of therms, was chalked up during 1954. Actual sales were higher than preliminary estimates indicated. The AGA's index of total gas sales, using 1947-1949 as a base of 100, gave 1954 an index of 198.3.

COATING & WRAPPING MACHINES

Line Traveling Over-the Ditch or Stationary Yard and Railhead types

Machines for every job are available — for pipe from 2" to 36", for any coating and wrapping combination from single-coat, single wrap to double-coat double-wrap. Perrault's years of field experience have developed the most efficient, most dependable equipment you can find. And Perrault's earnest desire to give customer satisfaction assures you of the best service to be had. You'll do better when you call Perrault Equipment Company.

Sole Owner, W. O. DIXON

ALSO: Cleaning and priming machines — line traveling or stationary. Glass Pipe Wrap, Asbestos Felt Wrap, Kraft Wrap, and Rock Shield. Tar-Heating Kettles, Burners, Patch Pots and Accessories.

•

AND: Pneumatic-Tired Lowering-In Cradles, Adjustable Pipe Cradles, Five-roller Cradles, Tongs, Hooks, Blocks, Belts, Slings, Line-up Clamps, Hand Tools, Supplies and Equipment of every sort.

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Short Gas Line To Be Built in Canada

Among the few natural gas pipe lines assured of starting construction in western Canada this year is the extension of the Canadian Western Natural Gas Company, Ltd.'s trunk line in southern Alberta to build services for three more towns. The extension will be laid from Lethbridge to Raymond, Magrath and Cardston, all south of Lethbridge in the direction of the Montana border. All have voted in favor of awarding a franchise to the utility company.

The work will include 58½ miles of 16-in. from Lethbridge to Cardston, from which the other lines will be taken off, and a new compressor station built at Lethbridge. Estimated cost of the whole extension will be $1,000,000.

First field testing of Caterpillar's new No. 583 pipe-layer was made recently on the R. H. Fulton spread on a 30-in. loop job for Panhandle Eastern Pipe Line Company in Kansas. The crawler-mounted unit is shown at work on pipe doping operation, a job normally requiring three sideboom tractors.

United Gas Planning $8 Million Expansion

United Gas Pipe Line Company has asked the FPC for permission to construct some $8,300,000 in new facilities on its transmission system in Mississippi, Alabama, and Florida. The project includes 63 miles of new pipe line and a new 330-hp compressor station. The facilities are planned to supply more gas to existing customers and a new industrial customer.

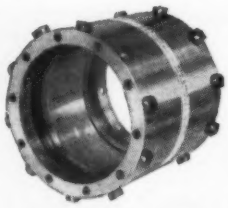
ODM Pipe Line Study Release Due Soon

A study of oil pipe lines in relation to national defense, long underway by the Office of Defense Mobilization, may be presented to the National Security Council sometime in May. Two chief items of interest are the West Coast Pipe Line and American Pipe Line projects, both proposed by private groups. The government agency is expected to recommend against any federal aid to either of the projects.

Texas-Florida Gas Line Proposed

A 1500-mile natural gas line costing $185,000,000 has been proposed by two Houston firms, Houston, Texas, Gas & Oil Corporation and Coastal Transmission Corporation, who have indicated they would ask the FPC for authorization in the near future. The line would transport gas from Texas and Louisiana production areas to Miami, Florida, and serve intermediate points.

Weld+Ends Permits Welding a Pipeline While Pumping Through It.



A pipeline safety welding coupling for crude oil, gas, gasoline, asphalt, steam, chemical process and other pipelines. WELD+ENDS joins pipe securely so flow can be resumed immediately at full pressure. Welding can be performed while pipeline is in use days or weeks later. Sizes 2" to 30".

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5700 Detroit Avenue Cleveland 2, Ohio

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Pipeline
Cleaner

for BETTER cleaning of
CRUDE LINES
PRODUCT LINES
NATURAL GAS LINES

FOR DETAILS WRITE

Pipeline Cleaners Co.
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NOTICE: Specify PELCO Welding Saddles

No change except the corporate name. We still have the same ownership, same management, same address, same telephone, and use the same 45 years of experience to render the same service under the same trade name—"PELCO."

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P. O. Drawer 1108 Shreveport (84), La.
SEE YOUR NEAREST SUPPLY HOUSE
(Formerly: Pelican Well Tool & Supply Company)

Loop Program Planned By California Companies

Pending approval from the California Public Utilities Commission, Southern Counties Gas Company is ready to start construction of 31.5 miles of 30-in. pipe line between Cactus City and Desert Center in Riverside County. The $2,500,000 project will complete "looping" of the California-Texas pipe line system along the 210-mile stretch from the Colorado River to Los Angeles. The "Biggest Inch" pipe line was first put into operation in 1947, at which time its daily capacity was 175,000,000 cu ft. Indicative of Southern California growth, currently the line delivers 713,000,000 cu ft each day. The line is owned jointly by Southern California Gas Company, Southern Counties Gas Company, and their out-of-state supplier, El Paso Natural Gas Company. Continuing expansion of the facility has run investment by the three companies to more than $210,000,000 and it is expected that in 1955 it will provide about 65 per cent of the primary gas supply to Southern California.

New Firm, Pipe Line Technologists, Formed

C-R-C Engineering Company, pipe line design engineering firm has been dissolved and a new engineering firm, Pipe Line Technologists, with the same management and personnel under sole proprietorship of Herbert E. Fisher, has been organized.

Home offices will be located in Houston, Texas, at 2518 North Boulevard, with branch offices in New York City and Calgary, Canada. The new firm will continue to offer complete engineering services for crude oil, natural gas and petroleum products pipe line systems.

Pipe Line Technologists will continue to manage and supervise the operations of Kaneb Pipe Line and Augusta Pipe Line Companies, consisting of a $10 million products pipe line system in Kansas and Nebraska.

ASCE Pipe Line Meeting Scheduled for St. Louis

A luncheon and technical session have been slated by the Committee on Pipe Lines of the American Society of Civil Engineers at the group's meeting in St. Louis, June 17. Speakers will include N. E. Tanner, president of Trans-Canada Pipe Lines, Ltd., on his firm's proposed system; Rear Admiral John R. Perry, CEC, USN, Chief of the Bureau of Yards and Docks, on the "Defense Pipe Lines in Spain," and Professor M. G. Spangler of Iowa State College, who will discuss "Stresses in Pressure Pipe Lines and Protective Casing Pipes."

Gulf Interstate uses Blue Flag to help protect new "BIG INCH"

BLUE FLAG

Machine wrapping the Gulf Interstate 30" main line over the ditch. Blue Flag's high tensile strength permits high-speed application with less downtime.

Gulf Interstate selected Blue Flag pipe wrap to help prevent corrosion on portions of its new 1160-mile pipeline system extending from southern Louisiana to West Virginia.

Pipeline enamel reinforced with Blue Flag has increased strength, offers exceptional resistance to cracking. Blue Flag protection adds years to the service life of a pipeline, helps safeguard the huge original investment.

Blue Flag pipe wrap is made of special inert glass by Glass Fibers' exclusive "Electronic-Extrusion" process. The fine fiber mat has uniform porosity which improves enamel distribution and greatly reduces the number of "holidays." Local Blue Flag distributors give quick service.

NEW FREE FOLDER—Learn more about L·O·F Glass Fibers' complete line of pipe wraps engineered for effective corrosion control. Write: L·O·F Glass Fibers Company, 1810 Madison Ave., Toledo 1, Ohio.

L·O·F GLASS FIBERS

L·O·F GLASS FIBERS COMPANY

Makers of glass fibers by the "Electronic-Extrusion" process

A COMPLETE LINE FOR PIPELINE PROTECTION

BLUE FLAG Reinforcing Pipe Wrap, **DURAMAT** Protective Outer Wrap, **DURAMESH** Pipeline Fabric, **DURATAPE** Pipe and Joint Wrap

Pacific Northwest Asks Financing Okay

Pacific Northwest Pipe Line Corporation has asked the Securities and Exchange Commission to approve a stock sale to finance construction of its recently FPC-approved system.

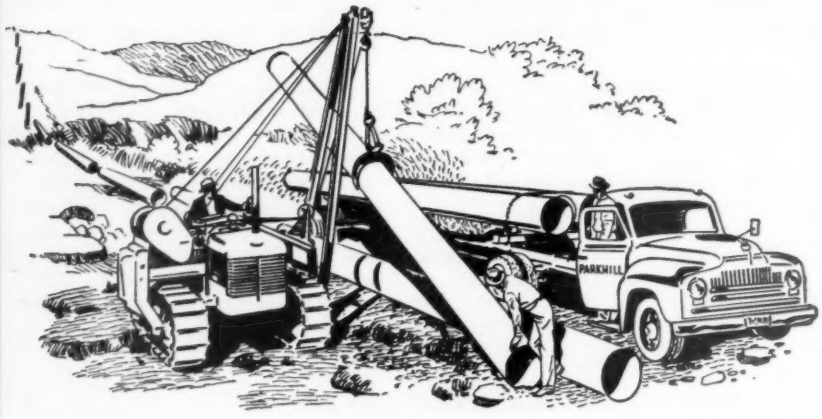
Financing plan of the $161,000,000 project includes:

1. Sale to present stockholders of 1,549,100 shares of common stock at $10 a share.
2. Public sale of 287,000 units consisting of $60 interim notes and one share of common stock—a $70 package for a total $20,090,000.
3. Issuance of $93,200,000 in first mortgage bonds at 4¼ per cent.
4. Issuance of $26,800,000 in unsecured notes at 3½ per cent.
5. Issuance of $5,654,000 unsecured notes to Phillips Petroleum Company for lease rights to 70,000 acres in the San Juan Basin.
6. Unsecured notes totalling $675,000 at 3¾ per cent interest to Colorado Oil & Gas Corporation.
7. A further issue to present stockholders only of 280,000 shares of one dollar par value common stock at $10 a share at the rate of .4 shares of new common for each outstanding share.

Whether they're "Pipe-Dreams" or "Nightmares" Turn Your Pipe Stringing Problems

over to

PARKHILL



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Panhandle Eastern Plans $22.4 Million Expansion

A combined $22,400,000 expansion program has been submitted to FPC for approval by Panhandle Eastern Pipe Line Company and its subsidiary, Trunkline Gas Company. The program would boost Panhandle's peak day delivery capacity by 250,000,000 cu ft. Trunkline would furnish 80,000,000 cu ft of the new capacity through expenditures of $18,700,000 for new facilities. Balance of the increased capacity would come from a big underground storage development by Panhandle near Waverly, Illinois, at a cost of $3,700,000.

Ten-Fold Increase In Gas Construction

Gas industry construction expenditures have increased more than tenfold since the pre-war years. Such expenditures have risen from an average of $101,000,000 spent each year from 1937 through 1941, to an average of $799,000,000 in the five immediate post-war years following 1945. In each of the years since 1950, the nation's gas facilities have been increased by the expenditure of $1 billion a year or more.

Tabulated construction expenditures for gas utility and pipe line construction in **millions** of dollars follow:

Average, 1937-1941	$ 101
Average 1946-1950	799
Total for 1951	1,462
Total for 1952	1,067
Total for 1953	1,350
Total for 1954 (prelim.)	1,108
Total for 1955 (estimated)	1,395

Ohio Oil's Columbus Terminal Completed

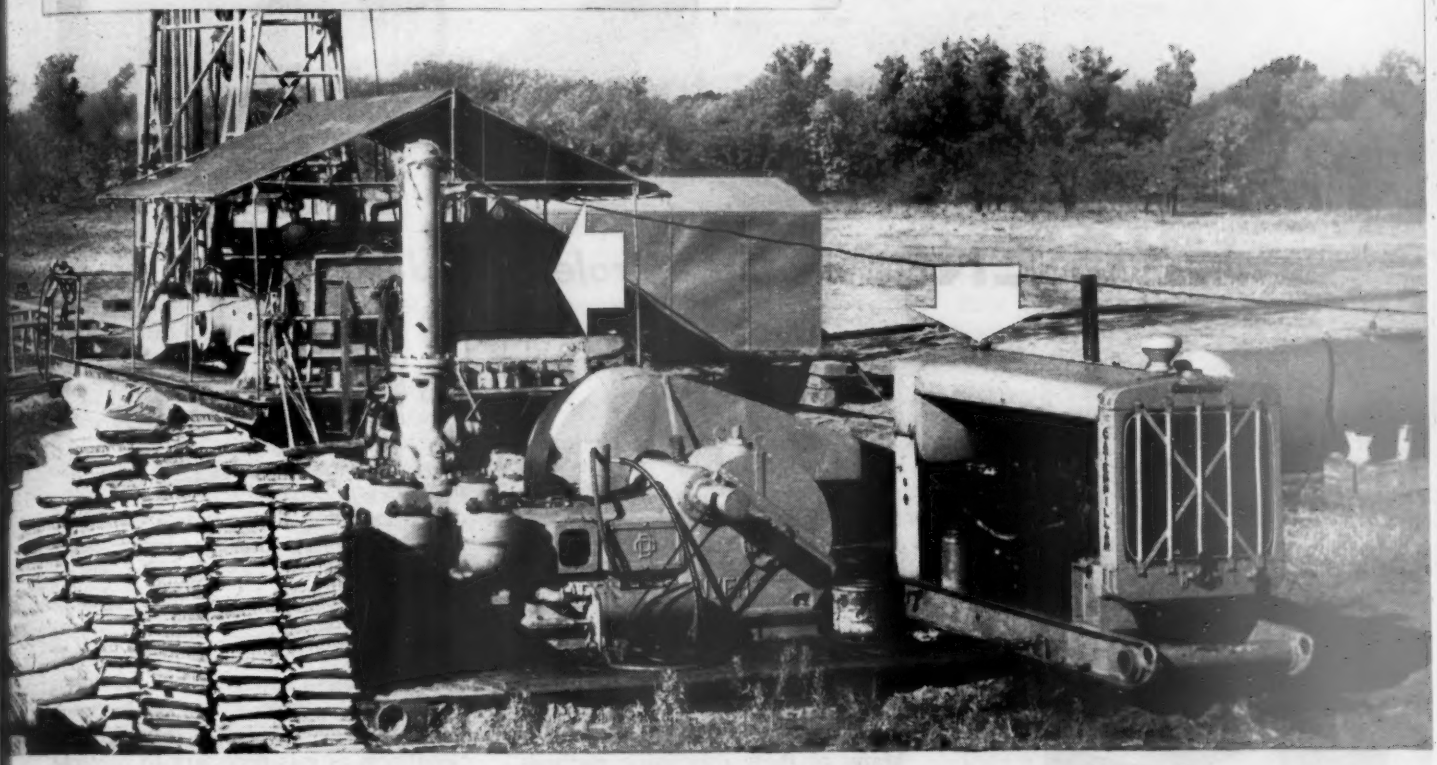
Completion of Ohio Oil Company's products pipe line terminal under construction at Columbus, Ohio, has been targeted for May.

The new 30-acre terminal will incorporate the latest facilities and techniques in products distribution. It will be serviced by an extension of a products pipe line from the company's Robinson, Illinois, refinery. The terminal will have a total of 260,000 bbl of storage.

Southern Gas Association To Meet in New Orleans

Some 2000 persons are expected to attend the forty-seventh annual convention of the Southern Gas Association when it meets in New Orleans May 16-17-18. Included in the sessions during the three-day meeting will be discussions of interest to pipeliners on accident prevention, plastic pipe, the new ASA pipe code, employee relations, and natural gas transmission problems.

TWO 18-YEAR-OLD D13000s



POWER 50,000 FEET OF DRILLING IN ONE YEAR WITHOUT DOWN TIME

Tom Jack Drilling Company, Ardmore, Okla., bought two Caterpillar Oilfield Engines in 1953. They were 130-HP D13000s built in 1937.

Last year this pair of rugged diesels powered 50,000 feet of hole without down time due to engine failure.

"Because of the efficiency of these CAT* Oilfield Engines," reports owner Tom Jack, "we were able to pay out the rig in less than two years and acquired oil production worth $40,000. The best part about Cat power on a rig is its economy of operation. And the cost of fuel is practically negligible."

The engines power a Gardner-Denver mud pump and Cardwell draw works. Including moving time in and out, the unit drills a 2000-foot well in seven days.

The story of Tom Jack's two D13000s is the story of Caterpillar economy. Not only do Cat Oilfield Engines have a long life, but they stay on your job without a lot of repairs and lost time. Because they have few adjustments, the engines need little attention. Their efficient filters and seals keep harmful dust and abrasives out of working parts.

It's never too late to cut costs. Get high production on your rig now with dependable Caterpillar Oilfield Engines. Your nearby Caterpillar Dealer will show you a complete power line up to 520 HP and 315 KW for new drilling equipment or repowering.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Both Cat and Caterpillar are registered trademarks—®

MODERN HEAVY-DUTY OILFIELD POWER

XUM

Tool of the industrial hygienist: The midget impinger, an instrument which draws a measured volume of air through a trap containing a liquid collecting medium. Here, the midget impinger is being used to sample atmospheric concentration of toxic dust.

INDUSTRIAL HYGIENE *in the Petroleum Industry*

A. C. Pabst, industrial hygienist, Socony-Vacuum Oil Company, Inc., is called in at the blueprint stage where basic hygiene measures can be incorporated into plants, processing units and other installations, helping to save time, money and problems for management.

A. C. Pabst

THE petroleum industry has made remarkable and enviable progress not only in developing new and better products, but equally in anticipating market demands in terms of both quality and quantity. It has an extraordinary record for providing the customer with what he wants, where and when he wants it. New processing methods have been necessary, of course, to achieve these results.

Many of these processing methods represent highly complex chemical operations that present problems and situations new to the industry. With foresight and planning, the petroleum industry is solving these problems, and, in fact, anticipating situations so that they do not become problems. To accomplish this, comparatively new sciences like health engineering are studied with the same zeal as other types of research. Practically unknown 20 years ago, today's occupational health includes the fields of industrial hygiene and industrial medicine.

Because industrial hygiene is one of the newest phases, many people do not know the meaning of the term, or the functions of the industrial hygienist. Nevertheless, the safeguarding of industrial health already is on a business basis, with labor and management recognizing its importance. Government, too, takes an active interest, and 19 states have health department rules on industrial hygiene. Today, there are only about 800 industrial hygienists in the United States, and a large number of this group are not in industry, but are working for the federal government or state departments.

People hearing the word "hygiene" usually recall they had a hygiene course in high school which dealt with personal habits such as bathing, cleaning the fingernails, teeth, etc., and immediately jump to the conclusion that an industrial hygienist in industry must be interested in keeping employees clean. In my first visit to many of our refineries, it seemed that I was always taken first to the locker rooms and toilets to inspect shower and lavatory facilities. Of course, industrial hygienists are interested in the employee's cleanliness as it is necessary to protect his health, but their primary interest is not in sanitary facilities. They are more interested in keeping an employee's lungs, skin, and other organs free from exposure to hazardous gases, liquids, dusts, and other harmful substances.

The petroleum industry is becoming increasingly involved in the handling of all kinds of chemicals having various degrees of physiological effects on man. These chemicals might be described by quoting from a publication issued by duPont's Haskell Laboratory of Toxicology."

"It Takes All Sorts"

"Chemicals, like people, can be mild, fractious and often exasperating.

"Like people, chemicals are of many types and dispositions. Most are uncomplaining, law-abiding citizens who present no special problems. Some are unstable and unpredictable. Some are out-and-out neurotics, requiring a sharp and observant discipline. Others, harmless by themselves, may be influenced by bad company. Still others are troublemakers in solitary, but docile and helpful in tandem. Some are just plain bad actors."

EXCLUSIVE

Many of the compounds with which the petroleum industry is concerned are new or are being studied more fully. The industry's concept of industrial hygiene compares favorably, however, with similar activities in chemical and other industries, which have worked many years on these problems.

The advent of catalytic cracking resulted in the production and handling of aromatic hydrocarbons with health problems similar to those long associated with the coal-tar industry. The use of new chemical catalysts, inhibitors, and other chemical compounds creates health problems that the chemical industries have faced for years. To illustrate this trend we need only look at the modern gasolines, fuel oils and motor oils. Years ago motor oils were practically 100 per cent petroleum in nature with little, if any, additives; today they contain up to 15 to 20 per cent of chemicals, additives and inhibitors. This trend doubtless will continue because there is no question that additives contribute much to improve performance characteristics. With every change in formulation, any business makes careful studies regarding the health and safety of personnel and customers. Problems that may arise are solved, many of them by industrial hygiene.

Hygiene is defined as that branch of medical science that relates to preservation of health, and therefore, industrial hygiene may be defined as the science of prevention and control of occupational illness. It resolves itself into the problem of looking for any factors or conditions in work places that could cause or contribute to illness or serious discomfort of employees, and of devising the methods and means of eliminating or controlling such conditions.

The typical industrial hygienist usually started out as a chemist or chemical engineer who became interested in and studied toxicological effects of chemicals on man. Consequently, he has a good background of chemistry and engineering combined with some medical knowledge—a sort of one-third doctor, one-third engineer, and one-third chemist. His objectives are the protection and improvement of the health and safety of workers in the industrial environment from all manner of harmful exposures related to occupation. In the petroleum industry, industrial hygienists usually function as an important part of the medical department and in close collaboration with the safety department for the protection of employees.

Basically, the practice of industrial hygiene in the petroleum industry is the same as in any other industry, and it can be boiled down to four general principles:

The midget impinger is to be used for air sampling in a refinery work area.

1. A knowledge of the toxicology of chemicals and materials.
2. A review of all chemicals or materials used or produced, how handled and the tabulation of toxic or potentially hazardous substances.
3. The measurement of worker exposure to toxic substances.
4. The recommendation and installation of adequate control measures and the evaluation of the effectiveness of such corrective steps where indicated.

Toxicology of Chemicals

In regard to Item 1, the toxicology of chemicals, it is difficult to give an adequate definition of a toxic material because practically anything can be safe or harmful depending upon how it is used or where it is used. For example, air and water are not regarded as harmful, but both are quite deadly under certain conditions—air if injected into the blood stream and water if introduced into the lungs. In the same manner, the use of carbon tetrachloride in a process having proper ventilation would not be hazardous, while the use of carbon tetrachloride for mopping floors would be quite dangerous. In other words, a toxic material may be hazardous or nonhazardous, depending on the conditions of its use.

In regard to toxicology, there are three ways in which a harmful substance can cause adverse effects upon man:

1. It can be ingested or swallowed.
2. It can come into direct contact with the skin or parts of the body.
3. It can be inhaled as a gas, vapor, mist, or dust.

Ingestion

Fortunately, petroleum materials are not commonly or intentionally taken internally and therefore, trouble from this is rather rare in a refinery, although it occasionally does occur unknowingly. I recall watching a worker who had been complaining of stomach trouble, whose duties involved the compounding of litharge or lead oxide in a doctor solution—this man proceeded to empty the bags of litharge into an outdoor mixing tank and, because of the dust and mists generated, he correctly wore a respirator. Of course, his hands were covered with lead oxide, and to my amazement, the first thing he did when he came down from the catwalk was to take from his lunch box an orange which he started to peel and eat, probably one of the most effective ways to get lead poisoning.

When petroleum products get to the consumers, ingestion is more frequent, but nearly always its occurence is a result of carelessness or mishandling. Small children whose parents carelessly leave products within easy reach may have unhappy experiences. We have had hurry calls from doctors involving children drinking kerosine or such products as penetrating oil and fly sprays. Sometimes adults are even worse. There are cases of anti-freeze poisoning, drinking of brake fluid and one, I recall, of a radiator flush that contains muriatic acid and chlorinated hydrocarbons. This occurred despite the fact that the product was fully labeled, including poison warning with skull and cross bones.

It should be emphasized that hardly a substance exists that is not capable of producing adverse effects on the human body if taken in sufficient quantity or

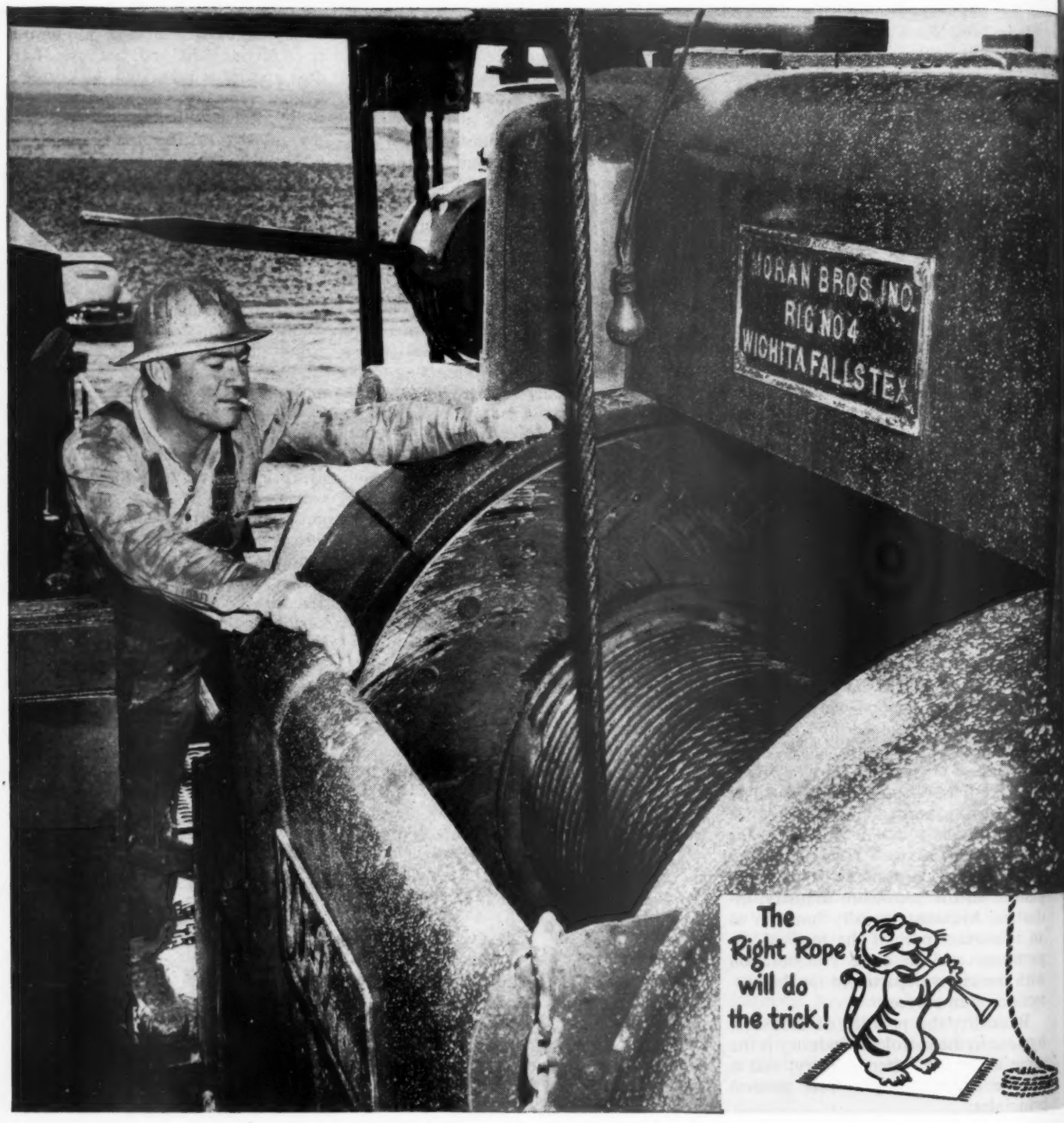
TABLE 1. Average effect of alcohol level in blood.*

Ounces of whiskey consumed in 1 hr or less	% alcohol in blood	Behavior
¾	0.01	Normal
1	0.02	Feeling of warmth, pleasant social behavior.
2–3	0.05	Judgment blunted, Boastful, impulsive, Officially still sober.
5–6	0.1	Fumbling, staggering gait, clumsiness, slurred speech.
8	0.15	Officially drunk. Responses and motor coordination strongly affected.
10	0.2	Helpless, nausea
16	0.3	Stupor
24	0.4– 0.5	Coma
30	0.6– 0.7	Paralysis of the respiratory center—Death.

*Pfizer Spectrum, JAMA, March 27, 1954.

XUM

"We won't use anything but for drilling lines and



Tiger Brand winch lines"

says **Mr. R. J. Moran,** *Vice President*
Moran Brothers, Inc.,
Wichita Falls, Texas

MORAN BROTHERS INC. have drilled oil wells all over the Southwest. They have learned how to drill a well on contract — *at a profit.* And they've learned that their best buy in wire line is Tiger Brand. Here's what R. J. Moran told us:

"We find that Tiger Brand Line *costs us less* than any other make we've tried—regardless of price. That's because Tiger Brand lasts longer and gives us the best ton mileage.

"Right now, we're averaging about 11.2 ton miles per foot of hole *without even lubricating the lines.* We just don't have time for maintenance with our rigs running constantly. Once a line is installed it doesn't get touched till it's replaced. Tiger Brand works so well under these conditions that we use it on *all* our rigs—both rotary and cable tool—and also on our winch trucks."

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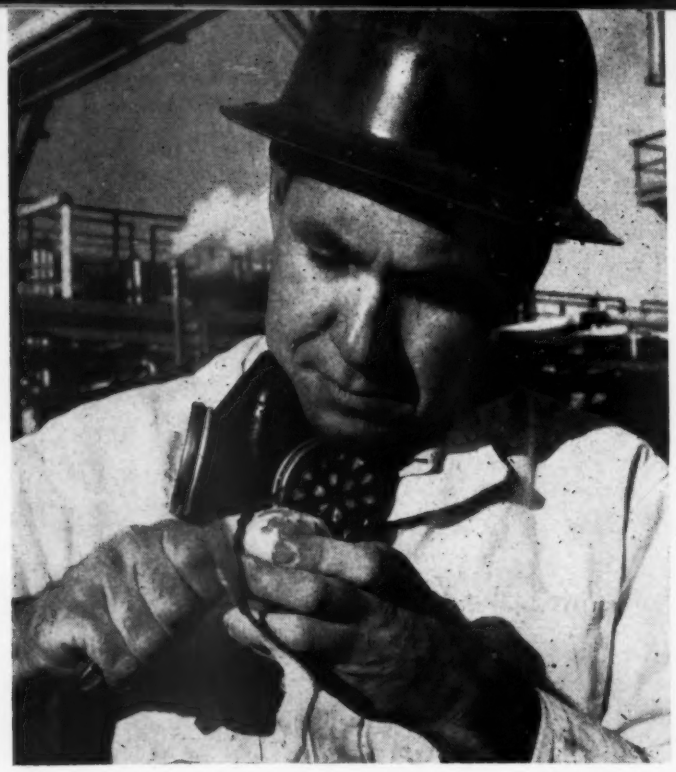

Problem for the industrial hygienist: Instructing employees in the proper handling of toxic materials. This posed shot represents an actual instance where a worker, handling lead oxide, neglected to wash his hands before eating. If his careless habit had not been corrected, he would have had a real health problem.

It should be a part of any occupational health program to educate employees in the correct handling of materials and to warn of the hazards of excessive exposure. Here, a kettle is being charged with a chemical which generates toxic dust. Note use of respirator, gloves, ventilating equipment, and coverall.

under wrong circumstances. Even common table salt is toxic if taken in sufficient amounts. It is reported that many years ago, the Chinese used table salt as a means of committing suicide. Every chemical, therefore, has a nontoxic dose and at toxic dose. This can be well illustrated by Table 1 on a widely used commodity.

Skin and Body Contact

In the petroleum industry, skin contact is not generally experienced to the extent that it is, for example, in the metalworking industries where a daily eight-hour contact with cutting oils often takes place. Cases of oil dermatitis are uncommon among our employees but they are reported not infrequently among industrial users of petroleum products.

It is definitely established that skin is not an impermeable barrier to chemical substances. In fact, it is increasingly important as a route of absorption for many materials. Regarding external or local skin effects, chemicals may be classified either as primary irritants or sensitizing agents.

A primary irritant is a chemical that may cause dermatitis in individuals, frequently after only one contact. It may have a strong chemical action, like acid, alkalis, amines, etc., or it may have a weak chemical action and require prolonged contact to cause dermatitis. Most petroleum hydrocarbons are primary irritants but are usually weak irritants since prolonged or extensive contact is generally required to cause skin irritation. The petroleum industry now is handling large quantities of chemical additives and inhibitors, many of which are strong primary irritants and are active chemical compounds.

It should be a part of any occupational health program to educate employees in the correct handling of such materials and to warn of the hazards of exposure. Recommendations and instructions also are given for protective equipment like respirators, goggles, gloves, and aprons.

This applies to concentrated or undiluted inhibitors. Finished petroleum products should and usually do contain such a small quantity of additives and in such dilution that there is scarcely more harm in the finished product than there would be from straight mineral oil itself.

Bizarre and erroneous conclusions sometimes are drawn in industrial dermatitis cases as to their cause, even by those who should know better. I recall a case of a young man who worked in a gasoline station and developed a severe dermatitis. He went to a physician who made patch tests on him and found he had a sensitivity to special gasoline but practically no reaction to regular gasoline. Apparently, the physician had heard special gasoline contains a lot of lead because the case was diagnosed as resulting from an excess of lead tetraethyl in the special gasoline. We thought this strange because lead tetraethyl is not a primary skin irritant and never has been known to cause dermatitis, although it is known to be a poison and can be absorbed through the skin.

A review of records of gasoline shipments into the particular area showed the regular gasoline actually contained the same or sometimes more lead than the special gasoline, clearly indicating that lead tetraethyl was not to blame, but that some other material was responsible, possibly the coloring agent.

Inhalation

Of the three avenues by which chemicals can be taken into the body, inhalation probably has received the most study and investigation because it is the avenue of greatest importance in industrial operations. From a vast amount of research has come publication of very useful data on safe human exposure levels known as Threshold Limit Values or Maximum Allowable Concentrations. This is a list of several hundred commonly encountered chemicals, solvents, dusts, etc., the toxicology of which has been carefully studied by medical research and industrial experience.

The list is compiled annually by the American Conference of Governmental

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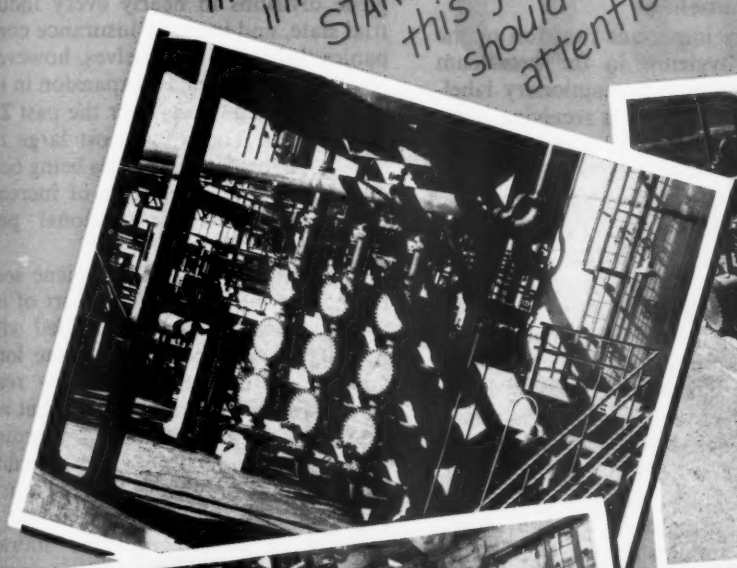

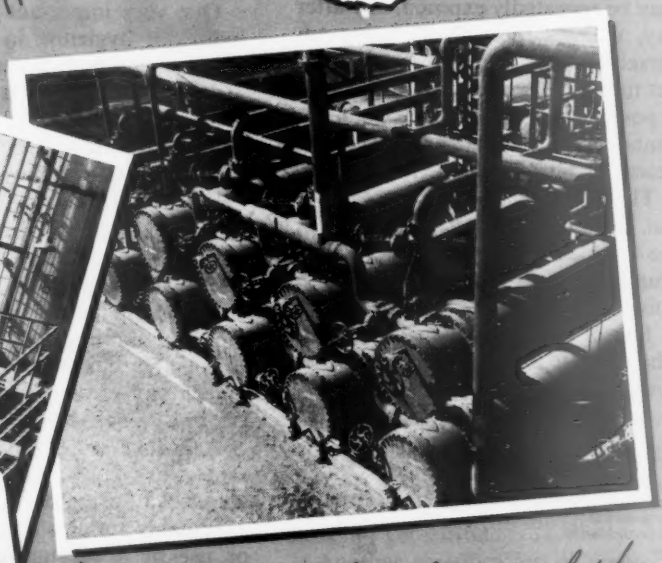

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Industrial Hygienists and is published by the American Medical Association in AMA Archives of Industrial Hygiene and Occupational Medicine. Introductory paragraphs define the values as follows:

"Values are given in the following tabulation for the maximum average atmospheric concentration of contaminants to which workers may be exposed for an eight-hour working day without injury to health.

These values are based on the best available information from industrial experience, from experimental studies, and, when possible, from a combination of the two. They are not fixed values but are reviewed annually by the Committee on Threshold Limits for changes, revisions, or additions as further information becomes available. Threshold Limits should be used as guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. They represent conditions only

They represent conditions only within which it is felt that workers may be repeatedly exposed, day after day, without their health being adversely affected. It is felt, at the present time, that workers should not be exposed to a working environment containing any of these substances in excess of the value indicated.

These values are not intended for use, or for modification for use, in the evaluation or control of community air pollution or air pollution nuisances."

A few of the materials encountered in the petroleum industry and their Threshold Limits are listed below:

Gases and Vapors

Substance	Parts per million
Benezene (benzol)	35
Carbon dioxide	5000
Carbon monoxide	100
Carbon tetrachloride	25
Gasoline	500
Hydrogen sulfide	20
Naphtha (petroleum)	500
Octane	500
Sulfur dioxide	10

Toxic dusts, fumes, and mists

Substance	Milligrams per cubic meter
Iron oxide fume	15
Lead	0.15
Sulfuric acid	1

Mineral dusts

Substance	Millions of particles per cubic foot
Asbestos	5
Dust (nuisance, no free silica)	50
ilica	
high (above 50% free SiO_2)	5
medium 5 to 50% free SiO_2)	20
low (below (5 % free SiO_2)	50

Nineteen states observe Threshold Limit Values in their laws or regulations, and more are sure to follow. Industrial hygienists, as part of their duties, advise management of the existence of these requirements in order that precautionary measures may be taken to avoid excessive exposure of personnel.

Industrial hygienists undertake measurement of air contaminants for compliance with states' codes. Even a common material like gasoline has a maximum safe level which is 500 parts per million.

The following are just a few of the hazardous materials that are encountered in petroleum refinery operations:

Materials encountered in petroleum refinery operations

Respiratory irritants	Toxic materials	Skin irritants
Acrolein	Aniline, liquid	Acids—all kinds
Acetaldehyde	Aniline, dyes	Amines
Aluminum chloride	Benzol (Benzene)	Benzol (Benzene)
Ammonia	Cadmium	Caustics
Asbestos	Carbon monoxide	Chromium salts
Ditertiary butyl para cresol	Chlorinated hydrocarbons	Coal-tar compounds
Dusts, physiologically inert, general	Chrome compounds	Cobalt, metal and compounds
Dusts, attapulgus clay	Cobalt, metal	Dyes
Dusts, bauxite	Hydrogen sulfide	Inhibitors
Dusts, catalyst	Inhibitors	Nickel salts
Formaldehyde	Lead, metal & fumes	Oils, general
Fluorides	Lead, oxide, litharge	Oils, high boiling aromatic
Furfural	Lead, tetraethyl	Oils, insoluable cutting
Inhibitors	Lead, soaps	Phenol
Lime	Manganese	Pitch
Nitrogen oxides	Mercury	Solvents
Ozone	Methanol	Ultra violet radiation
Pine oil	Radioactive materials, general	Wax, untreated
Silica	Toluol (Toluene)	
Smoke	Xylol (Xylene)	
Sulfur dioxide	Zinc	
Welding fumes		

Product Labeling

One very important function of the industrial hygienist in the petroleum industry concerns precautionary labeling of products. This is receiving more emphasis as state after state passes labeling regulations. One of the most recent is the State of New York, where on February 26, 1954, the Council on Public Health passed labeling regulations which became effective August 26, 1954, as Chapter IX-A of the New York State Sanitary Code. These labeling regulations have the force and effect of law and require precautionary labeling on any product that entails a hazard in a reasonably anticipated use.

A hazard is defined as "the risk of injury or illness which may be encountered during or as a result of any reasonably anticipated type of handling or use of a substance, or during its specified use, if any, by reason of toxicity of the substance through ingestion, inhalation or absorption through the skin, or due to its corrosiveness or irritating properties, or because of its flammability or explosiveness."

Somewhat similar labeling regulations already exist in California, Illinois, New Jersey, Oregon, and the Territory of Hawaii and are in the making in many other states, so more can be expected. Most state regulations are guided by recommendations of the Manufacturing Chemists' Association, Inc., and with some exceptions, conformity in one state results in conformity in other states.

It is recognized that, as a rule, labeling of many products is advisable and results in safer handling of the material by customers. However, this requires extensive work, knowledge of product, and toxicological information to determine what products must be labeled and how they should be labeled.

Prior to 1932, only a handful of persons were engaged in industrial hygiene procedures. By the end of the next decade, there were industrial hygiene divisions in nearly every industrial state, and in many insurance companies. Industries themselves, however, have made the greatest expansion in industrial hygiene units over the past 22-year period. Today, in most large industries, industrial hygiene is being conducted under the guidance of increasingly well-trained, professional personnel.

No longer is industrial hygiene seen by industry as an "aimless effort of intellectuals collecting bottles filled with nothing so that they can prepare long and useless discourses that few read or understand or would know what action to take". Instead, the safeguarding of health is assuming a new significance. It not only saves time, money, and problems for management, but it actually improves employee morale and efficiency by eliminating apprehension in occupational environments.

Instead of telling what mistakes have been made and how to correct them with costly changes, industrial hygienists now are called in at the blueprint stage where their ideas can be incorporated into factories, machines and other installations to accomplish the most good easily and inexpensively.

Industrial hygiene at its best in the petroleum industry requires the cooperation and skills of industrial physicians, industrial nurses, toxicologists, chemists, safety men, and industrial hygienists working together as a team. American industry, particularly the oil industry, is aware of the benefits of more and better production derived from environmental control and health-promotional activities. It needs only to be guided in the application. * * *

ATOMIC ENERGY versus OIL

How Peaceful Uses of Atomic Energy May Affect Petroleum

Walter G. Whitman

ATOMIC energy is so relatively new that any valid overall appraisal of its effects is practically impossible today. But one conclusion is certain: Atomic energy can be completely catastrophic. It has already revolutionized military problems. It has markedly modified the foreign policy of the United States, and not only the United States but many other countries on both sides of the Iron Curtain. Potentially the destructive bomb will be developed and possessed by many other nations besides the three that now have it, United States, Russia, and England. It's ultimate effect on the possibilities of peace are quite incalculable. It may destroy civilization. On the other hand it may be the imperative challenge which will bring powerful nations to their senses and eliminate major wars.

The most highly publicized peacetime use of atomic energy is for the generation of electric power. Technically, this possibility has been recognized from the start because the controlled fission reaction will release tremendous amounts of energy and there are lots of ways in which you might consider capitalizing on that energy in a nuclear reactor. To date all of these ways which seem at all practicable, however, involve making steam and then using the steam to run turbines.

Among other types there are heterogeneous reactors and homogeneous reactors. A heterogeneous reactor has its fuel elements—the fissionable uranium or plutonium—in the form of a solid which can be a rod or a tube or a plate. A homogeneous reactor is one in which the fissionable material is in fluid form; it can be dissolved in water—ordinary light water or maybe heavy water—or in a liquid metal or fused salts.

The homogeneous reactors are very attractive to the chemical engineer because they give him a chance to design a continuous circulating process. But at the present time the heterogeneous reactors are further developed than the homogeneous. There are lots of problems not yet solved.

Another classification of reactors is based upon the energy of the neutrons at the time of fission. This is the difference between fast reactors and thermal reactors. In fast reactors the neutrons effect fission at the very high energies at which they are liberated whereas thermal reactors slow down the neutrons to a fairly low energy level before fission takes place.

The slowing down can be done by means of moderators. Water is a moderator; heavy water is a better moderator. Graphite and beryllium are moderators. Reactors can be described as graphite reactors, heavy water reactors, and the like. This refers to the method of slowing down the neutrons to get them into the thermal range. Thermal reactors are of the most interest for power in the near future.

This is a condensation of an address given before the Southwest Regional Conference sponsored by Southwestern Alumni Clubs of Massachusetts Institute of Technology in Dallas, Texas, January 29, 1955.

Other classifications of reactors are breeders and convertors. In a breeder a person may start with a certain amount of fissionable material and end up with more than when he began because he has capitalized on some material which initially was not naturally fissionable. Converters do not go as far as that. They do not make as much new material as they consume.

It is very attractive to think about having a breeder reactor, which will actually generate additional material—and it is perfectly possible theoretically but in practice exceedingly difficult. In the future it is probable that large breeder reactors will be in operation. They will be needed when the demands for fission material for atomic energy are so great that an adequate supply depends on breeding in a reactor.

There are several methods of cooling the reactor. Many are cooled by water but in some cases the cooling is done by helium, carbon dioxide, liquid sodium, liquid bismuth or even by a fused salt system.

Building Five Reactors

Last year the Atomic Energy Commission embarked on a program supporting five reactors to be built in a program of developing electric power from atomic energy. One of these reactors is a big one. It will be built by Duquesne Light Company with the Westinghouse Electric Corporation near Pittsburgh. It will be paid for primarily by the government although the Duquesne people will contribute quite largely to the development. This is a large demonstration reactor. Its purpose is to demonstrate that a large block of power can be produced steadily and fed into a regular power system.

No one has the slightest illusion that it is going to be economic. The power is going to cost a great deal more than equivalent power could be made by putting up a steam boiler plant. The other four plants in the program are really pilot plants. They are going to be much smaller in size but they will be prototypes, which will give enough engineering experience to justify going ahead with a big plant if the estimates show that the process is anywhere near reasonable. These four pilot plants are being handled by Union Carbide and Carbon at the Oak Ridge National Laboratory, two at the Argonne Laboratory in Chicago and one by North American Aviation.

Duquesne's demonstration plant will have a heterogeneous reactor where fuel elements containing the fissionable material are really immersed in a bath of ordinary water. They will be installed in a vessel which will stand very high pressure so that the fission process can go on. The water can moderate the neutrons and keep them down to the proper energy level; at the same time the water will take away the heat and then will be pumped around through another circuit. By maintaining very high pressure—which means a very expensive vessel must be used—it will be possible to avoid any boiling of the water in the reactor.

☆ ☆ ☆

The Author

The work of Professor Walter G. Whitman, head of the Department of Chemical Engineering at Massachusetts Institute of Technology, has contributed largely to increased efficiency in operations of various industries such as the recovery of gasoline from natural gas, the manufacture of liquid carbon dioxide and dry ice, the production of refrigerants for household use, and the manufacture of heavy chemicals. He was assistant director of research for Standard Oil Company of Indiana when in 1934 he rejoined the MIT staff. During World War II, Dr. Whitman was in charge of all basic chemicals for War Production Board. He was also chairman of the sub-committee on the Aircraft Fuels and Lubricants and of the National Advisory Committee for Aeronautics. He has recently been chairman of the Research and Development Board of the Department of Defense in Washington, D. C., and has been a member of the General Advisory Committee to the Atomic Energy Commission.

☆ ☆ ☆

The very hot radioactive water will be pumped through a heat exchanger and on the other side of the heat exchanger there will be water at lower pressure to develop steam for the steam turbines. The secondary circuit, where steam is made from ordinary water, of course, will not be radioactive. This is the system used in the Nautilus, the atomic power submarine.

A second type, the one which North American Aviation is working on, is based upon using sodium rather than water as the cooling fluid and employs graphite as the moderator. This is another heterogeneous reactor with solid fuel elements in it with sodium as the fluid that cools the reactor itself before the sodium is taken out through the heat exchanger. The heat for the sodium boils water to make steam for the turbines.

A third one is a quite neat device if it will work. It is called the boiling water reactor. Until recently it was thought that if the reactor were immersed in water the water must not reach a boiling point because if any steam were formed the system would go completely out of control.

The Argonne people found that they could let the water boil between the reactor fuel elements themselves with a certain degree of satisfaction.

This now forms the basis for a scheme where the reactor itself is the water boiler. It makes the steam and the steam comes off the top of the reactor and goes to the turbines. There are many difficulties. In a system of this sort the water gets tremendously radioactive and the steam will be somewhat radioactive so the turbines and condensers will get slightly radioactive. It will be possible only by actual experiment to find out whether the system will operate satisfactorily. If it can be done, however, it will eliminate the entire intermediate system of making steam in a separate heat exchanger or boiler.

Competitive Fuel?

The economic problem can be somewhat oversimplified but it almost comes down to the fact that you are substituting energy from fission for energy from coal, oil, or gas to make steam. This is on the assumption that we haven't yet found some better way of using atomic energy than making steam for power. Therefore to be competitive with power from coal or oil or gas in the United States the investment costs and the total cost of the system must come down to a reasonable competitive range. That means that while fuel cost may be cut, we learn how to build a plant with an investment that is somewhere close to the investment in a steam boiler. That is a pretty tough challenge. In other words, the atomic energy plant that is going to be built near Pittsburgh may cost about $1000 per kilowatt of capacity and it really ought to be down in the $200 range to be competitive.

Experience is accumulating all the time, new materials are being developed, and so are new methods. Incidentally, industry as a whole is getting a great deal of potentially new material from the experimental work that is going on in development of atomic power reactors.

The new Atomic Energy Act makes it much more practicable for private industry to get involved in private generation of power. The Atomic Energy Commission is now putting out feelers to see what might be developed. On the tenth of January they put out two releases, one of which marked a rather important step in establishing a schedule of prices that the AEC would charge a company if it wanted to buy or rent such materials as uranium 238, 235, etc.; also prices it would pay for plutonium or used fuel elements, or the like. These prices have not been pub-

licly announced. The announcement merely says the prices are set for a seven-year period and companies that are interested and that have the necessary clearance can see them. The other announcment concerned the AEC's desire to get proposals from industrial groups for building plants to make power. The AEC expects to be involved in subsidy for these first big demonstration plants. Applicants willing to assume the risk of construction, ownership, and operations of reactors designed to demonstrate the practical values of such facilities are to send their proposals to the AEC and let the Commission decide whether any are practical enough to be supported with AEC funds.

The method of support is to rent out fissionable materials, fuel elements, and so forth, to the private producer and then waive any rental payment; or the AEC laboratories will perform research and development work pertinent to the development without charge; or the Commission can give a research and development contract to the applicant under which he is to supply technical and economic information resulting from the operation of his plant.

Many ask when will this atomic power come? This cannot be answered with accuracy. How well are these pilot plants going to run? Is it going to be possible to bring the investment down to any reasonable figure?

There is going to be a big expansion in the total demand for power so that it will be quite possible for atomic energy plants to come into the system, and be absorbed with all the other ways of making power expanding at the same time. Whether the present high degree of government support is going to be continued as a matter of policy is of course very important.

Experience with the military propulsion plants—the submarine and the aircraft plant—and with the small package power unit that the army wants so that it can establish a unit up in the Arctic or any place like that, will be helpful toward developing regular power plants for electric utilities.

The price of fuel—oil, coal, and gas —will influence future use of atomic energy.

It is quite probable that atomic power will be attractive in other countries before it is in the United States. Britain, for example, which previously exported coal, is now importing coal and oil. So the British are far more interested in fission than the United States. Brazil, which imports tremendous amounts of oil, is quite interested in it.

It is anybody's guess as to when atomic energy for electric power will become important. We are probably going to have a number of plants within the next 10 years. It is doubted whether any plants to make power will be built without subsidy. Looking ahead 50 years, we can almost inevitably forsee that atomic power will be a significant factor, even in the United States, although even in this case, one must remember there is no absolute law of nature which says that atomic power is going to be competitive.

Four years ago few persons thought that atomic power was needed in the United States. Attitudes have changed completely. It is now considered very vital to this country, not because the United States needs it today, because of any depletion of coal, oil, and gas, but because national interests demand that a great deal of effort be placed in it. Atomic energy must become a constructive force.

There are other evident uses of atomic energy entirely aside from the highly publicized electric power business. It may well be that the eventual benefits to man through application of atomic energy in biology and medicine will be far more significant than the electric power development from atomic energy. In the field of agriculture all sorts of possibilities are being explored. As examples we may mention the development of new and better strains by forced mutations, and studies of the movement of fertilizers into plants and through plants.

Neutron logging, gamma ray logging, and the setting of radioactive markers in wells are themselves examples of the application of radioactive particles. Techniques become available for "seeing" things underground and behind walls which give a much better understanding and a better way of attacking the problems of working where the eye cannot see.

President Eisenhower has proposed that an international agency be set up to disseminate information and offer help throughout the world in the peaceful development of the atom. The United States has agreed to give 100 kilograms of fissionable material to this agency. The British have agreed to give 20 kilograms to it.

The United States also proposed that an international conference be held for scientific exchange of information in this field. The General Assembly of the United Nations unanimously adopted it. The Russians have agreed to participate and this meeting will be held next August in Geneva.

This agency and this conference are bold moves to get us off dead center, to awaken a spirit of cooperation among nations and to make the atom man's servant rather than his destroyer. * *

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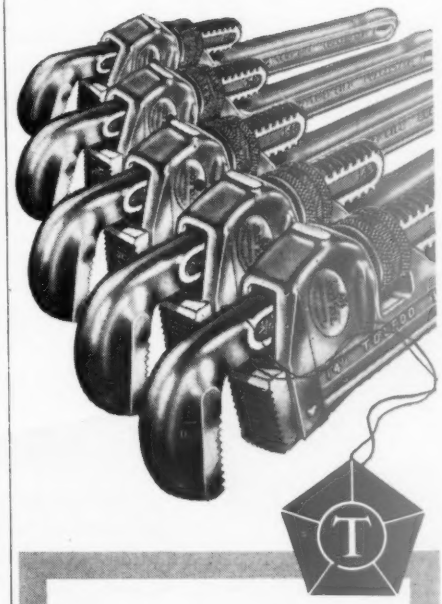

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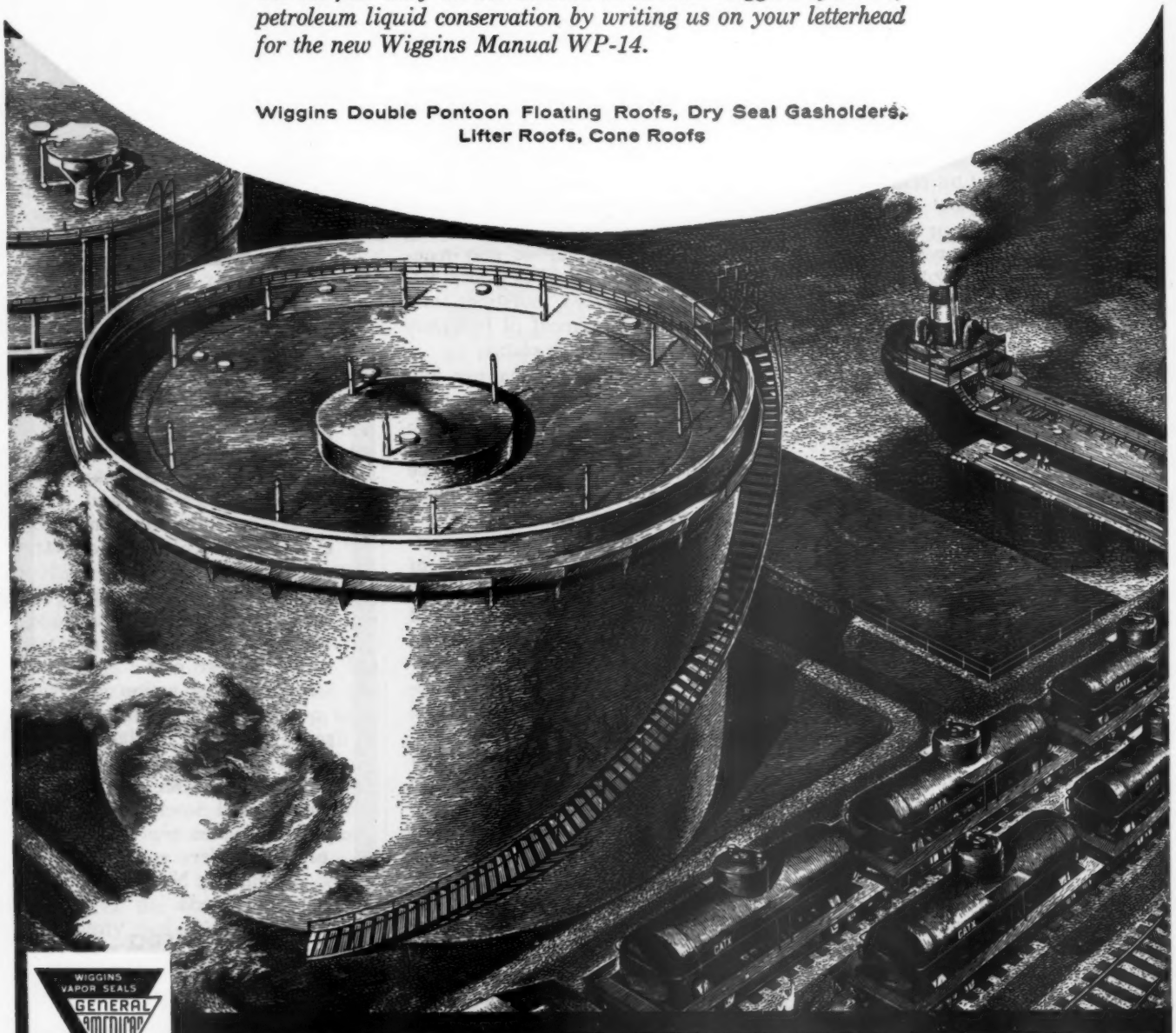

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TIPRO Thinks So

Can You TAX Petroleum Out of the Market?

Ernestine Adams

IN approving a study of tax-paying in Texas by various groups in agriculture, business, and industry and their distribution by school districts, city, county, and state, TIPRO made what promises to be the most far-reaching move in its nine years of existence. The association fears petroleum can be taxed out of the market.

TIPRO took a look at a lot of problems at its annual meeting in Fort Worth, March 27-29 and asserted its opinion on practically every question that came up. Usually the 1500 members present, who represent a membership of some 4000, were wholeheartedly for or against each question brought up. G. Scott Hammonds, chairman of the taxes and compensation insurance committee, presented the report on taxes. Here the committee looked far into the future and had come up with the proposition that the tax base of the State of Texas should be broadened so that all tax-paying groups, such as agriculture, oil production, refining, pipe lines, sulfur, chemicals, retail business, real estate, manufacturing, etc., pay proportionately according to their ability.

Joe Zeppa of Tyler pointed out that some people think ahead two years, such as the two years the state legislature is in session. Some think ahead 10 years which may be the end of an oil and gas lease, but the petroleum industry has to think ahead 25 years if taxes are to be distributed fairly, and the state does not become too dependent for its revenue upon one industry.

The report stated that the usual tendency of the industry is to look for oil and gas and produce it and pay no attention to outside factors, which in the long run may increase the cost of production and place the industry at a competitive disadvantage with other sources of petroleum or fuel.

Walter S. Hallanan received TIPRO award as "a true industry statesman."

Recommendations were that, for the short range, TIPRO oppose any increase in taxes on crude petroleum or on natural gas, until other classes of property had been brought to share their just burden of taxes through ad valorum and other forms of taxation available to the legislature.

The report stated that the committee believes the petroleum industry of Texas is paying more than its fair share of state taxes.

For the long range, the proposition was that a study should be made by an independent group over all tax-paying businesses in the state showing what taxes were paid by each group and breaking this down by school districts, county, state, and city. The study would also include an analysis showing the ability of each group to pay taxes. Then the study would be published and circulated so that it could be used as a guide for legislation in developing a more equitable tax program.

The project would help develop policies, programs, and plans on which a more factual approach could be made in fighting the tax burdens of the petroleum industry and in assuring the legislature the petroleum industry is already paying its full share of taxes.

The cost of the economic study would be so high that TIRPO felt it could not carry the load except in cooperation with other groups both in and out of the petroleum industry. *

At its ninth annual meeting in Fort Worth, March 27-29, members of the Texas Independent Producers and Royalty Owners Association:

- Heard a forum on the question of FPC control of gas production sold in interstate commerce. Moderator for the panel was Guy I. Warren and members were John F. Lynch, M. D. Bryant, Will Mann Richardson, Alwyn P. King, Jr., and Jack Woodward, 1954 TIPRO president.
- Affirmed the decision to continue the fight for competitive price for natural gas to the producers and landowners.
- Sent a resolution to members of Congress declaring that excessive imports must be corrected by Congressional action.
- Heard O. R. Strackbein, chairman of the Committee of Industry, Agriculture, and Labor on Import-Export Policy, describe the influence on U. S. industries of GATT (General Agreement on Trade and Tariffs).
- Presented Walter S. Hallanan, president of Plymouth Oil Company, and chairman of the National Petroleum Council, with the annual award in recognition of his fight for economic freedom.
- Resolved to oppose compulsory unitization and any state legislation that seeks either directly or indirectly to achieve compulsory unitization.
- Agreed to back the state legislation that would give the Texas Railroad Commission authority to regulate gas as well as oil production.
- Expressed appreciation to the members of the Congress who have worked diligently to maintain the depletion allowance as an incentive to encourage oil exploration and drilling.
- Elected Alwyn P. King, Jr., Houston, as president to succeed Jack Woodward; G. Scott Hammonds, Dallas, as secretary to succeed H. M. Christie; reelected W. T. Beard, Jr., San Antonio, as treasurer; and named Earl Turner, publicity director, as executive secretary, to succeed E. I. Thompson.
- Heard William Murray, Texas Railroad Commission, urge oil men to enlist the support of the consuming public in their fight against the three major problems facing the petroleum industry: 1. Defending the depletion allowance; 2. Amending the Natural Gas Act; 3. Keeping imports in hand.

Maryann Duggan examines corroded pipe.

Corrosion Expert

Maryann Duggan of Magnolia Petroleum Company in Dallas, Texas, tried hard to escape from the oil industry, but in the end it won her—and now a more willing captive would be hard to find.

The groaning, squeaking drilling rigs, the thudding monotony of pumps and the special lingo of oil-men-in-the-know were part of the life in which Maryann grew up. Her father was an oil man in Kilgore during the East Texas boom days.

Miss Duggan went to North Texas State College in 1942, studied medical sciences and biology, worked her way through school, was elected to Alpha Chi honorary society, and the Masters Chemistry Club. She thought she had come a long way from oil, but at graduation time when a card from Magnolia Petroleum Company arrived asking her to come in for an interview, Maryann went, was hired, joined the Control Laboratory as a chemist on January 1, 1945.

In 1947 she transferred to the Drilling Muds research group and in 1948 was promoted to the corrosion technical service section. This group investigates corrosion difficulties in drilling, production, and transportation; develops techniques for measuring severity of corrosion prior to actual loss of equipment, and makes recommendations for remedial measures.

"This job," says Maryann, "has led me to study the oil industry anew in all its phases. I've developed an intense interest in the study of the chemistry of formation waters and requirements for treating concentrated brines prior to subsurface injection. I assisted in the development of a punch-card classification system for natural waters."

Maryann is one of three women of the 2000-National Association of Corrosion Engineers membership. She is also a member of the American Chemical Society, The Texas Academy of Science, and the American Association for the Advancement of Science.

When she isn't out in the "oil patch" rubbing elbows with pumpers, production foremen, and farm bosses, Maryann is puttering around her home—with its half-acre lot and 25 trees. She likes it best when she has it full of people, but it is also a fine place to "get away from it all."

Mrs. Walker won Brand Names Award.

Miss Esso of New Iberia

Carmen Walker remembers the morning of May 5, 1950, like awakening from a bad dream. Her husband's sudden death had left her with three children—Robert, 10, Katherine, 8, and Jance, 5—to support, and a service station as her only means of livelihood.

She pulled on a pair of coveralls and went to work.

There were problems at the beginning. Her employees were not used to working for a woman—and "after all, who could blame them? It certainly isn't the most feminine of jobs!" she admits. She overcame their first reluctance by working right along with them, spending over 10 hours a day on the job. "Before long help was coming from all directions." She still has the same people her husband hired at the station.

Over the hump, Carmen enrolled in a typing course. Then she drove 40 miles three nights weekly to Southwestern Louisiana Institute to complete a speech course. "This I had to do to give me confidence in meeting the public."

Carmen Walker works as hard at being a good mother and a good citizen as she does at being a good business woman. She is a member of the P-TA, vice president of the alumnae group of her school, chairman of the Girl Scout movement, active in the Community Course, official chaperone of the Sugar Cane Festival Queens and their maids of honor.

Known wherever she goes as "Miss Esso," Carmen last spring was named top winner in the Gasoline Service Station division for brand names promotion by the Brand Names Foundation, Inc.

"I wasn't so concerned over winning," she recalls, "as I was in telling our story. We operate our Servicenter on the idea that courtesy and service are the backbone of all business. We service a constant stream of bikes for young customers and give balloons and suckers to the children. We provide free parking for three doctors' cars daily, run the unofficial baby sitter service in town, service free cars of all clergymen. We furnish our truck to transport high school ball clubs whenever it is possible."

Competition and a fighting spirit has certainly paid off for Carmen Walker. Her Servicenter does an annual business of $95,000, including about 225,000 gallons of motor fuel. A $12,000 remodeling job is in process. While she was in New York City receiving her brand names' award, New Iberia planned its own special salute to her—a Carmen Walker Day. The words of praise she heard served only as an incentive to greater accomplishments.

For this dynamic lady uses adversity and success alike as stepping stones to bigger things.

Oil Companies Receive Freedoms Awards

Five oil company publications received 1954 Freedoms Foundation honor medals or certificates according to Dr. Kenneth D. Wells, president of the Foundation. In addition, the Standard Oil Company of California received the top advertising award and the Sun Oil Company received an award for its daily news program. The Atlantic Refining Company and Union Oil Company of California also received honor medals for advertising.

Company publications receiving awards were: *Tide Water Associated News*, Tide Water Associated Oil Company, Thomas J. Freeman, editor; *The Connecting Rod*, Service Pipe Line Company, Carl I. Huss, editor; *Citiesentinel*, Cities Service Refining Corp., George Hebert, editor; *Sohioan*, Standard Oil Company (Ohio), Frances Kenney, editor, and *The Texaco Star*, Texas Company, Ellis Prudden, editor.

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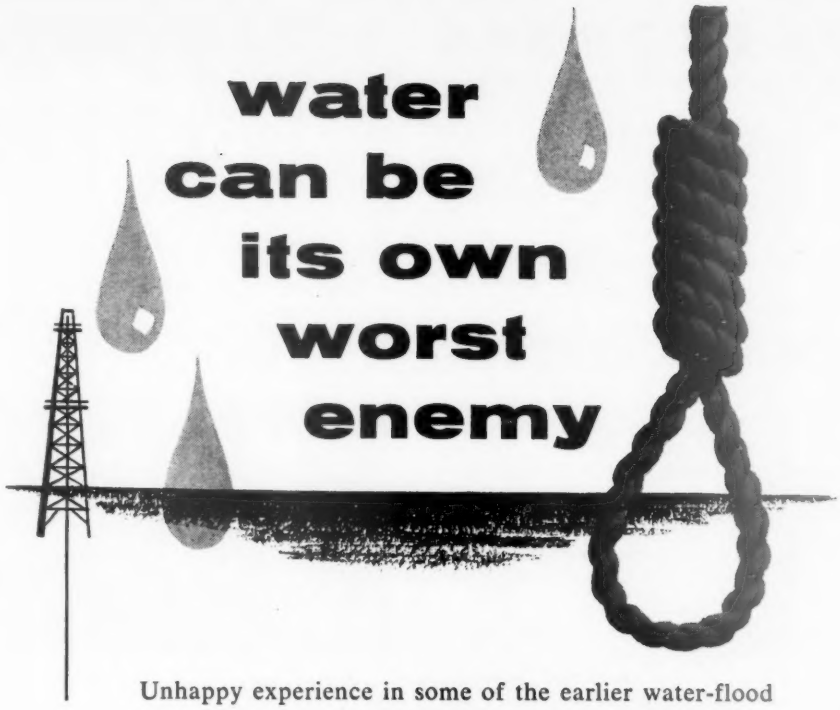

Unhappy experience in some of the earlier water-flood projects has demonstrated that the injection water itself may be the very thing which defeats the project . . .because it can carry into the formation the precipitants, algae and bacteria which have been established as major causes of formation-plugging.

But, today, many of the advanced water-flood projects now in operation have no trouble at all from this source. They have installed modern diatomite filtration systems and, using Dicalite filteraids, are filtering out completely the microscopic water-borne solids which could slow or halt the water drive. That's because Dicalite filtration is so "sharp" that it traps unwanted solids even down in the sub-micron size range: up to 95% of all bacteria can be removed by Dicalite filtration.

Diatomite filtration systems take up little room – about 1/5 that required for the older, less-efficient sand filters – and their installation costs are comparatively low. In addition, diatomite filter systems can be moved to another location when and if desired; in fact, some of the newer systems are completely unitized for easy hauling.

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PERSONALS

E. J. Anglin has been appointed by Sinclair Oil Corporation as assistant to Vice President **P. W. Thirtle,** principal budgetary officer of the corporation. Anglin had been a member of Sinclair's comptroller's department since 1948, prior to which time he was general auditor of Richfield Oil Corporation of New York, a Sinclair subsidiary.

The Oklahoma University chapter of Pi Epsilon Tau, honorary petroleum engineering fraternity, conferred honorary memberships upon **Dr. J. S. Karcher,** inventer of the reflection seismograph and president of Concho Oil Company, Dallas, Texas, and **Ernestine Adams,** management editor of *The Petroleum Engineer* magazine. Presentation was made at the annual banquet in Norman, Oklahoma, March 25. Miss Adams gave the address on "The World's Best Economic Missionary."

Phillips C. Salman has been appointed comptroller by Socony-Vacuum Oil Company, Inc. He succeeded **Louis E. Hanson,** who had been comptroller since 1946. Salman had been assistant comptroller

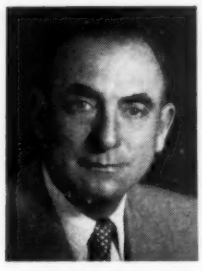
B. W. Pickard has been appointed as president of the California Oil Company. In assuming leadership of this East Coast subsidiary of Standard Oil of California, Pickard succeeded **E. W. Endter** who resigned as head of Caloil.

John Hammermann, Jr., Gulf Oil Corporation received a certificate of appreciation for his long service and contributions to the American Petroleum Institute's Safety and Fire-Protection Committees. Presentation was made by **R. E. Donovan,** chairman of the API's Central Committee on Accident Prevention and manager of safety for Standard Oil of Califoria, at the eighth mid-year meeting of the committees in New Orleans, Louisiana.

Jack A. Horner, secretary of Shell Oil Company, has been appointed vice president in charge of the licensing division of Shell Development Company. In addition to his new post with Shell's research affiliate, Horner will retain his present position with the parent company. An 18-year veteran with Shell, Horner has been its secretary since April, 1953. He joined the firm as a member of the legal department and was appointed assistant to the president in 1943. In 1949, he was named assistant secretary. He is a graduate of the University of Oklahoma.

Lawrence Wolff, executive assistant to the vice president of Union Oil of California, plans to retire from the company June 1 after 43 years of service. He started his Union Oil career in San Francisco in 1912 as a clerk. He was named executive assistant to Vice President **A. C. Stewart** in 1949.

Wolff has served as president of the Asphalt Institute, which he was instrumental in forming, and is a charter member of the Twenty-five Year Club of the Petroleum Industry.



R. H. Green

J. M. Little

Russell H. Green has been elected to the newly created position of executive vice president of the Signal Oil and Gas Company.

Harold F. Clary, a director of the company, has been named vice president and **A. E. Stebbings** was elected assistant secretary.

John M. Little has retired as vice president in charge of production for The Vickers Petroleum Company, Inc., after nearly 28 years of service. He had been a vice president since 1951.

Little is president and a director of the Jayhawk Drilling Company.

O. H. Berry, formerly chief production engineer has been named manager, production department, to succeed Little.

Emile E. Soubry, a vice president and director of Standard Oil of New Jersey, was elected a member of the company's executive committee.

Maury Goodin was elected president of the Petroleum Club of Denver, Colorado. Other officers are **O. L. Stalcup,** first vice president; **E. A. Polumbus,** second vice president, and **E. P. Tallant,** secretary-treasurer. New directors are **E. A. Polumbus, Jr., W. E. Glenn, R. H. Trompeter, G. W. Sandberg,** and **T. H. Hammett.**

George Y. McCoy has been elected president of the International Oil Corporation, Dallas, Texas, at the annual directors meeting. McCoy, a petroleum consultant in Dallas for the past seven years, had previously been with the oil loan department of the Republic National Bank since 1939, following a tenure on the petroleum engineering faculty of the University of Texas. Earlier employment was in exploitation and reservoir engineering departments of the Shell Oil and Skelly Oil Companies. He attended Oklahoma A&M College, the Colorado School of Mines, and the University of Kansas.

G. Y. McCoy

E. E. Fogelson, former president, became chairman of the board of directors, and **H. T. Baxter** was elected treasurer.

C. H. Campbell has been promoted to drilling superintendent for Holm Drilling Company, Tulsa, Oklahoma. **George W. Perry** was named assistant drilling superintendent and **Glenn Horton** is now toolpusher.

Robert G. Pearson, former manager of Shell Oil Company's news and information division in New York, has been appointed public relations representative in the New Orleans, Louisiana, area. He succeeds **Ty Scoggins,** who has been transferred to Los Angeles, California.

Tyler Brinker, engineer with Union Oil Company of California at Whittier, California, has been transferred to Houston, Texas.

Death Takes Two Oil Writers

Two well known oil industry writers, **Jerome B. (Jerry) Robertson** and **Dr. Carl Coke Rister,** have died recently.

Robertson was killed near Brenham, Texas, in an automobile-train accident. Publisher of the *Tri-State Oil Report* of Evansville, Indiana, he is the author of two recent books about the industry, *The ABC's and Oil Slanguage*. A familiar figure at many oil industry conventions, he usually wore colorful western attire.

Dr. Rister, educator-historian, was a distinguished professor at Texas Technological College, Lubbock. He had done six years' research for a complete history of the petroleum industry in America, due for publication in the next five years.

Speaker and international guests at the Los Angeles chapter, Nomads, in March were, standing, George Emerick, Egyptian American Petroleum, Egypt; Floyd M. Wells, D&E, Brazil; Patricio del Solar, ENAP, Chile; W. P. Ries, IPC, Qatar; seated, E. J. Scroggins, Shell, Venezuela; Florent Bailly, speaker; Jorge W. Gromsch, ENAP, Chile; Michel Court, N. N. Marep, France; Phil McConnell, recently from Saudi Arabia.

Officers of Houston, chapter of Nomads, 1955, are seated, W. L. Childs, Jr., Reed Roller Bit, president; W. O. Hedrick, McEvoy, vice president; E. M. Fontaine, National Tank, senior regent; standing, Harry E. Estes, Oil Well Survey, executive secretary; R. H. Franklin, Rollo Manufacturing, junior regent; F. M. Prell, A-1 Bit and Tool, sergeant-at-arms; B. H. Prickard, Tuboscope, assistant secretary; W. W. Londen, Baroid, treasurer.

XUM

DEATHS

Herbert L. Whitson, Sr., died recently in Los Angeles, California. He had been engaged in the oil business in the Fruitvale field, Kern County, for the past 25 years. He planned and built the Palomar refinery at Bakersfield and founded the Meridian Oil Company.

James Kenneth Murphy, Tulsa, Oklahoma, independent geologist, died in a Tulsa hospital after an illness of several years. He served as chief geologist for British-American Producing Company from 1938 until 1944. He helped form Norbla Oil Company and served as secretary-treasurer and geologist until 1951. He was president of Miners Oil Company from 1951 to 1952.

Thomas Daniel Hanratty, retired assistant superintendent of Gulf Oil Corporation's pipe line department, died recently in Tulsa, Oklahoma.

Earl A. Richardson, who organized Fargo Oil Company in 1921 and headed the firm for 25 years, died recently in Denver, Colorado.

Willard R. Spence, treasurer of The Buckeye Pipe Line Company, died recently in New York City after a very short illness. He had been with the company for 25 years.

Vaughn George Hutchins, California independent oil producer, died recently in Los Angeles.

John I. Cairns, 51, retired Richfield Oil Corporation executive, died in St. Francis Hospital, Lynwood, California, after a long illness.

John Henry Swain, partner in the Coker & Swain Drilling Company, died recently in Taft, California. Swain was also a senior member of Petroleum Production Pioneers, Inc.

George M. Adams, retired executive of Standard Oil Company of California, died recently at his home in Los Angeles.

W. A. Roberts, president of Allis-Chalmers, died of a heart attack in Milwaukee, Wisconsin, April 12. He had headed the company for four years.

Auguste Jean Paris, Jr. died recently in Bradford, Pennsylvania. He had developed a process for getting natural gasoline from natural gas at the turn of the century and during the last war operated an experimental station at Charleston, West Virginia, for extracting aviation gasoline from natural gas.

Nathaniel Trahan died recently in Lake Charles, Louisiana. He was a retired foreman in the production department of Union Sulphur and Oil Company.

Rex L. Brown died recently in Regina, Saskatchewan, Canada. He was chief chemist of Imperial Oil, Ltd.'s Regina refinery.

William A. Goforth, founder and former president of Valley Osage Oil Company, died recently in Tulsa, Oklahoma.

William Greenlay, assistant manager of the public relations department of Standard Oil Company of California, died of a heart attack recently on board an airliner flying between Guayaquil, Ecuador, and Lima, Peru.

Arthur C. Wright, who worked for Shell Oil Company, died recently in New Orleans, Louisiana. He was crude oil representative for Shell's Denver office.

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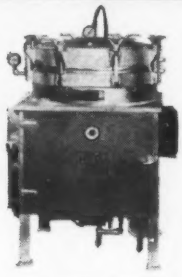
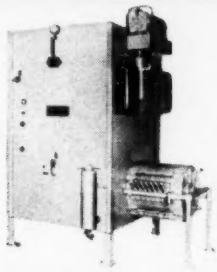


OIL RECLAIMER

For continuous oil purification in range of 2-100 gph. Removes all solids, acids and volatile contaminants.



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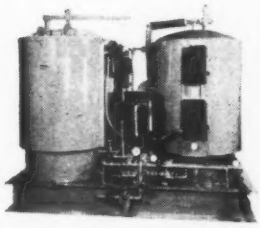

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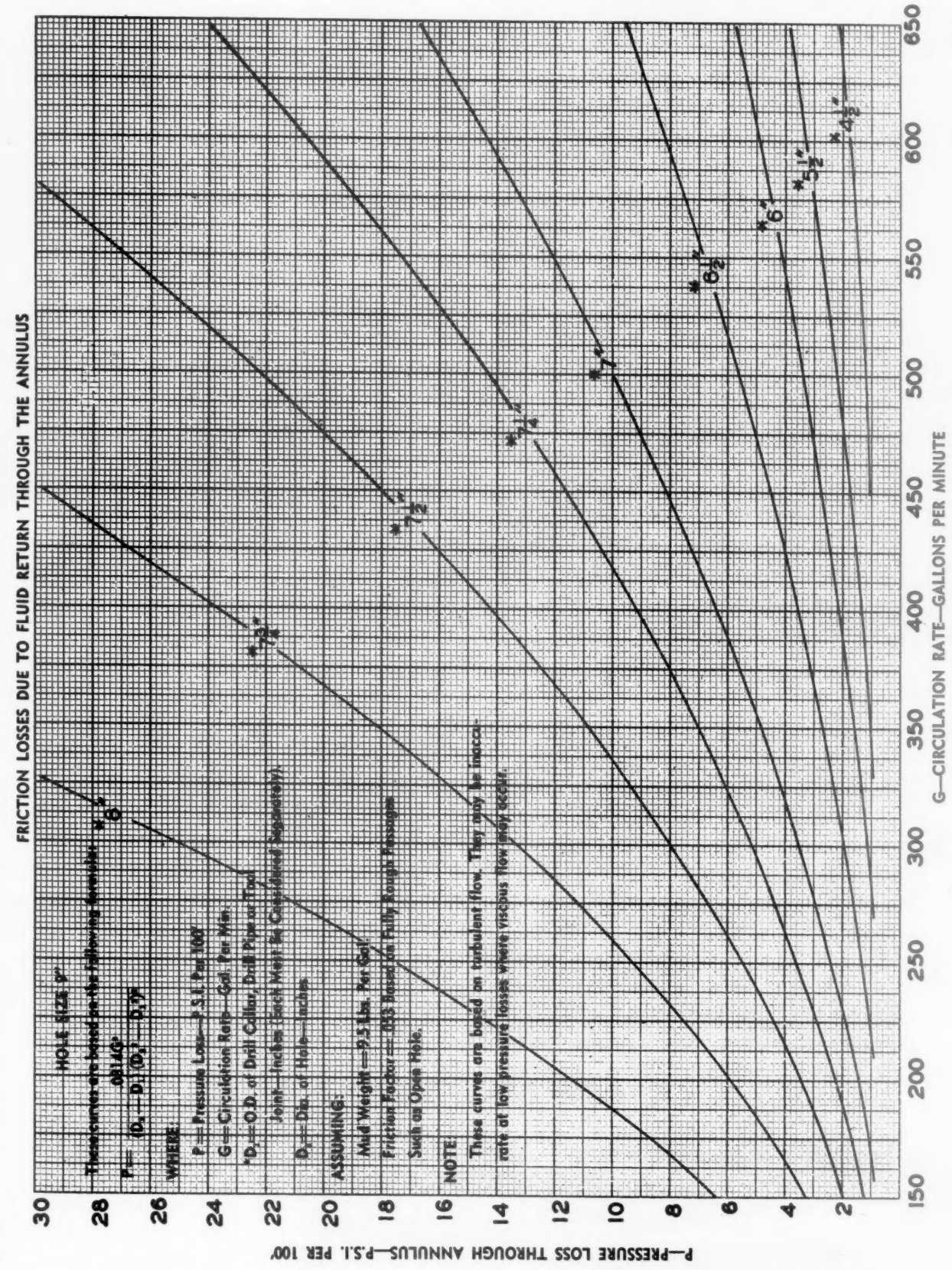

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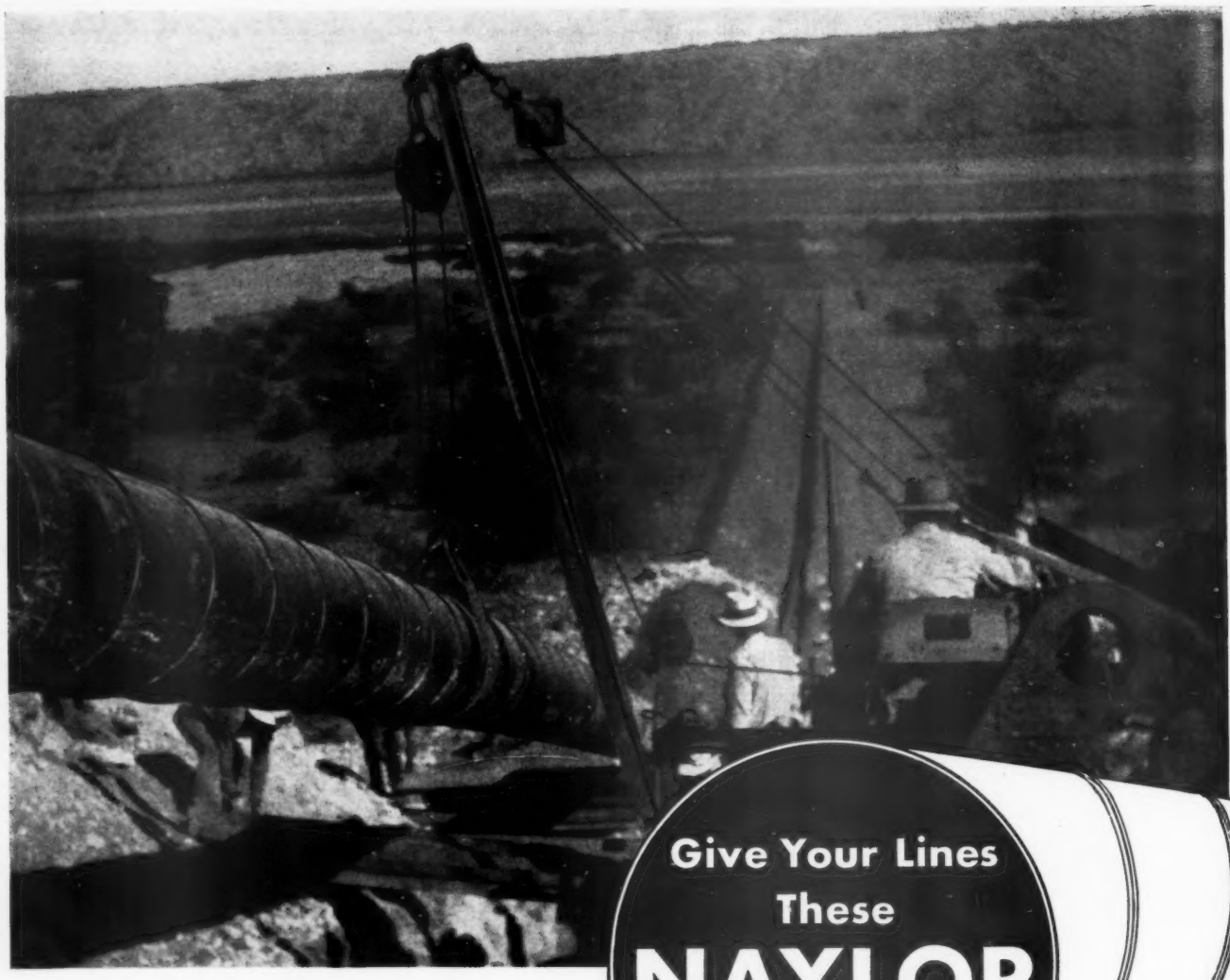

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TONS (LONG) (Continued)

1.12	tons (net)
1,016.0470	kilograms
2,722.22	pounds (Troy)
2,240	pounds (Avoir.)
10,160.470	hektograms
101,605	dekagrams
32,667	ounces (Troy)
35,840	ounces (Avoir.)
1,016,047	grams
10,160,470	decigrams
101,604,700	centigrams
1,016,047,000	milligrams
15,680.000	grains
261.333	drams (Troy)
573,440	drams (Avoir.)
653,333	pennyweights
784,022	scruples
5,080,320	carats (metric)
6.19755	barrels of water @ 60° F.
7.33627	barrels of oil @ 36° API
28.607	cubic feet
260.02971	gallons (U. S.) liquid

TONS (METRIC) =

0.984206	tons (long)
1	tons (metric)
1.10231	tons (net)
1,000	kilograms
2,679.23	pounds (Troy)
2,204.622341	pounds (Avoir.)
10,000	hektograms
100,000	dekagrams
32,150.76	ounces (Troy)
35,273.96	ounces (Avoir.)
1,000,000	grams
10,000,000	decigrams
100,000,000	centigrams
1,000,000,000	milligrams
15,432,365	grains
257,206	drams (Troy)
564,384	drams (Avoir.)
643,015	pennyweights
771.618	scruples
5,000,086	carats (metric)
6.297	barrels of water @ 60° F.
7.454	barrels of oil @ 36° API
29.0662	cubic feet
264 474	gallons (U. S.) liquid

TON (NET) =

0.892858	tons (long)
0.907185	tons (metric)
1	tons (net)
907.184872	kilograms
2,430.56	pounds (Troy)
2,000	pounds (Avoir.)
9,071.84872	hektograms
90,718.4872	dekagrams
29,166.66	ounces (Troy)
32,000	ounces (Avoir.)
907,185	grams
9,071,849	decigrams
90,718,487	centigrams
907,184,872	milligrams
14,000,000	grains
233,333	drams (Troy)
512,000	drams (Avoir.)
583,333	pennyweights
700,020	scruples
4,536,000	carats (metric)
5.71255	barrels of water @ 60° F.
6.76216	barrels of oil @ 36° API
32.04	cubic feet
239.9271	gallons (U. S.) liquid

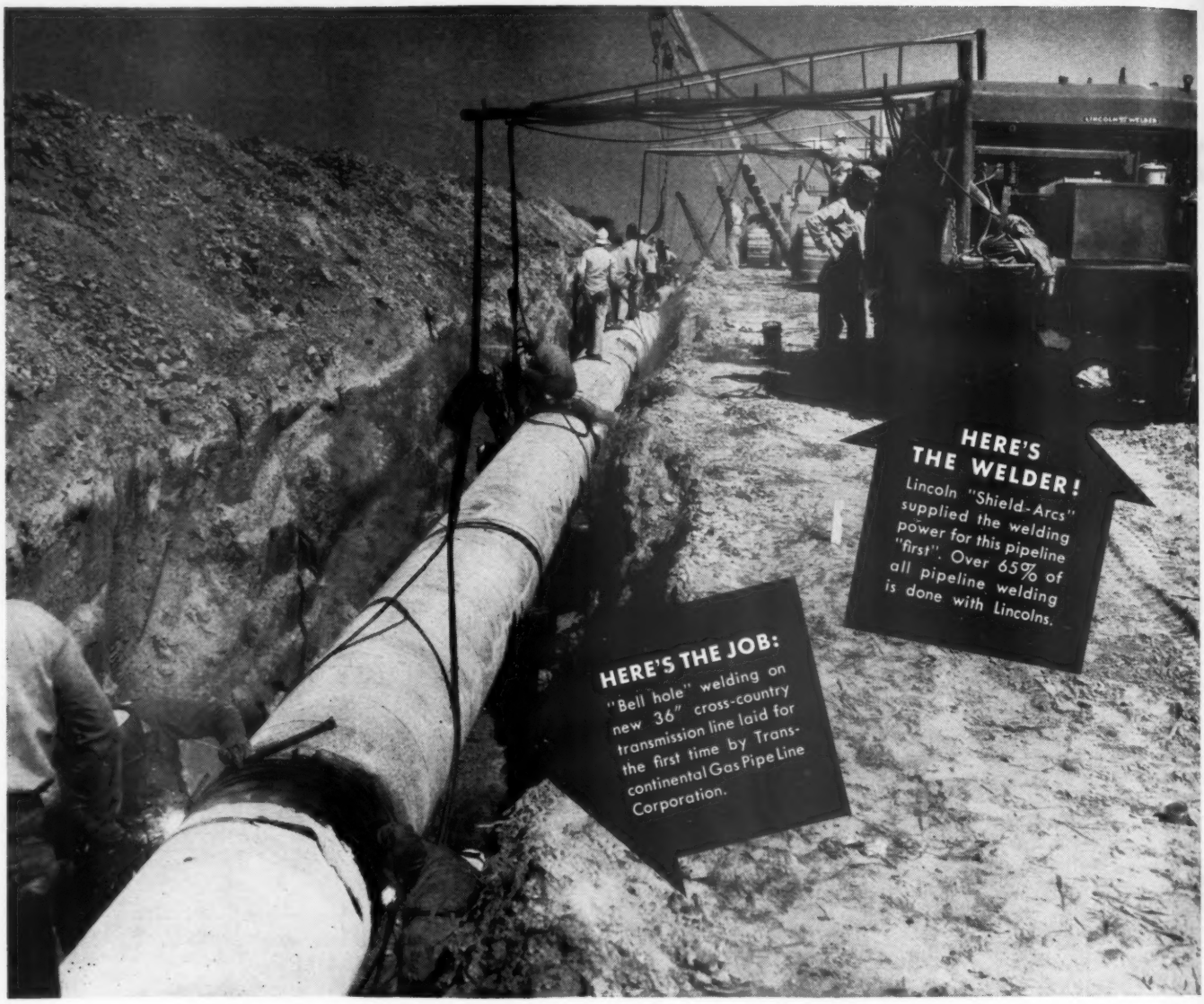
CHAIN (SURVEYOR'S OR GUNTER'S) =

0.0125	miles
0.020117	kilometers
0.1	furlongs
0.20117	hektometers
2.0117	dekameters
4	rods
20.117	meters
22	yards
23.76	varas (Texas)
66	feet
88	spans
100	links
198	hands
201.17	decimeters
2,011.7	centimeters
792	inches
20,117	millimeters
792,000	mils
21,117,000	microns
21,117,000,000	milli microns
21,117,000,000	micro millimeters
31,244,672	wave lengths of red line of cadmium
21,117 x 10^9	Angstrom Units

DEGREE PER MINUTE =

4.0	revolutions per day
0.16667	revolutions per hour
0.0027778	revolutions per minute
0.000046297	revolutions per second
15.99869	quadrants per day
0.66661	quadrants per hour
0.01111	quadrants per minute
0.00018517	quadrants per second
25.13203	radians per day
1.04717	radians per hour
0.017453	radians per minute
0.00029088	radians per second
1,440	degrees per day
60	degrees per hour
1.0	degrees per minute
0.016667	degrees per second
1,440	hours per day
60	hours per hour
1.0	hours per minute
0.016667	hours per second
86,400	minutes per day
3,600	minutes per hour
60	minutes per minute
1	minutes per second
5,184,000	seconds per day
216,000	seconds per hour
3,600	second per minute
60	seconds per second

Compiled by Steven Gerolde, Gulf Oil Corporation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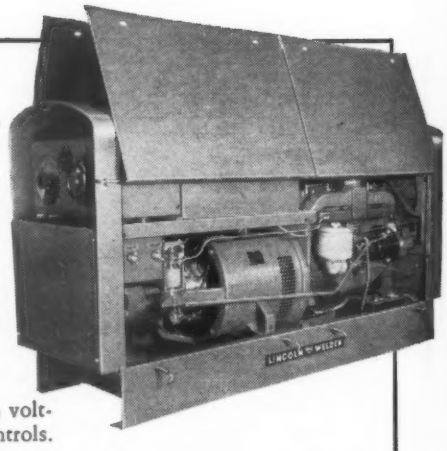
Dual Continuous Control instantly provides right type arc and right arc intensity. Only Lincoln manufactures welders with exact and continuous control on both voltage and current controls.



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XUM

Typical Tensile Properties of Aluminum Alloys Employed in Heat Exchanger Construction

Lowest strengths during 10,000 hours of heating at testing temperatures.

Alloy and Temper	Temperature, °F ①	Tensile Strength, psi.	Yield Strength, psi. (Offset = 0.2%)	Elongation, % in 2 in.
3S-O①	—320	33,000	8,500	46
	—112	19,500	7,000	42
	0	17,000	6,000	41
	75	16,000	6,000	40
	212	13,000	5,500	43
	300	11,000	5,000	47
	400	8,500	4,500	60
	500	6,000	3,500	65
	600	4,000	2,500	70
	700	3,000	2,000	70
Alclad 3S-O②	Properties are substantially the same as those for 3S-O			
3S-H14	—320	35,000	23,000	30
	—112	23,500	19,500	18
	0	22,000	19,000	16
	75	21,500	19,000	16
	212	20,000	17,000	16
	300	17,000	13,500	16
	400	13,000	8,500	20
	500	7,500	4,000	60
	600	4,000	2,500	70
	700	3,000	2,000	70
Alclad 3S-H14	Properties are substantially the same as those for 3S-H14			
4S-O②③	—320	43,000	13,000	38
	—112	29,000	10,000	30
	0	27,000	10,000	26
	75	26,000	10,000	25
	212	26,000	10,000	25
	300	21,000	10,000	35
	400	14,000	9,500	55
	500	10,000	7,000	70
	600	7,000	4,500	85
	700	5,000	3,000	95
Alclad 4S-O②③	Properties are substantially the same as those for 4S-O			
A54S-O②	—320	51,000	17,000	40
	—112	37,000	15,000	32
	0	35,000	15,000	28
	75	35,000	15,000	25
	212	35,000	15,000	30
	300	29,000	15,000	40
	400	22,000	13,000	45
	500	16,000	8,000	65
	600	10,000	5,000	90
	700	6,000	3,500	120
61S-T6	—320	60,000	47,000	22
	—112	49,000	42,000	18
	0	47,000	41,000	17
	75	45,000	40,000	17
	212	42,000	38,000	18
	300	34,000	31,000	20
	400	19,000	15,000	28
	500	7,500	5,000	60
	600	4,500	2,500	85
	700	3,000	2,000	95

①It is recommended that for unfired pressure vessels fabricated from aluminum alloys the maximum metal temperature be about 400°F.
②For welded construction the design is usually based on the annealed (—0) properties regardless of the original temper.
③For design purposes the properties of the annealed temper (—0) are used when 4S or Alclad 4S is supplied in the —H112 temper.

Nominal Composition of Wrought Aluminum Alloys④

Alloys⑤	PER CENT ALLOYING ELEMENTS—ALUMINUM AND NORMAL IMPURITIES CONSTITUTE THE REMAINDER					
	Copper	Silicon	Manganese	Magnesium	Chromium	Zinc
3S	....	...	1.2	...	....	...
72S	....	...	...	...	....	1.0
4S	....	...	1.2	1.0	....	...
52S	....	...	...	2.5	0.25	...
A54S	....	...	...	3.5	0.25	...
61S	0.25	0.6	...	1.0	0.25	...
63S	....	0.4	...	0.7	....	...

④Temper symbols have been omitted since composition does not vary for different heat-treatment practices and for the different cold-work tempers. The suffix H14 designates an intermediate cold-work temper.
⑤ "S" designates wrought alloy.

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There's No Denying These Facts...

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Most Efficient By Any Comparison

. . . for refiners using catalytic processes including: cracking, reforming, alkylation, polymerization, isomerization, desulfurization, hydrogenation and dehydrogenation.

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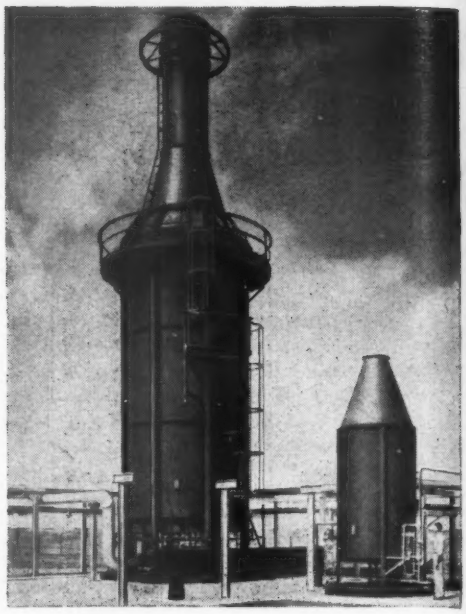
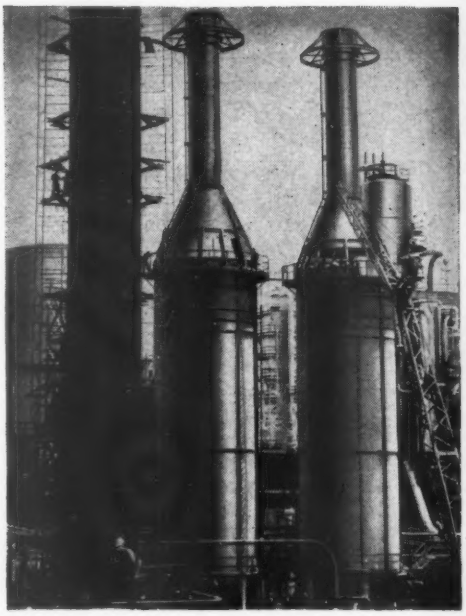
- UNIFORM HEAT DISTRIBUTION
- MAXIMUM FUEL EFFICIENCY
- PLENUM CHAMBERS FOR HAZARDOUS AREAS
- SIMPLICITY OF DESIGN AND CONSTRUCTION
- EXCESS DRAFT FOR HIGH OVERLOAD
- EXPLOSION RESISTANT
- MINIMUM GROUND SPACE
- SHORT LENGTH OF LIQUID TRAVEL
- ZERO AIR LEAKAGE
- LOW PRESSURE DROP
- LOW MAINTENANCE

In every case where these 11 all-important design characteristics were employed to compare one type of furnace design with another, PETROCHEM-ISOFLOW FURNACES were proved most efficient by any comparison.





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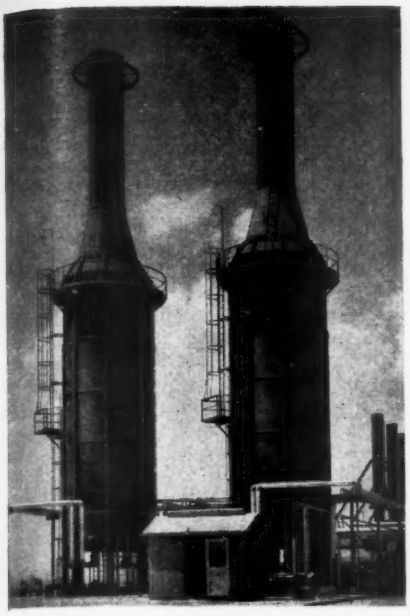

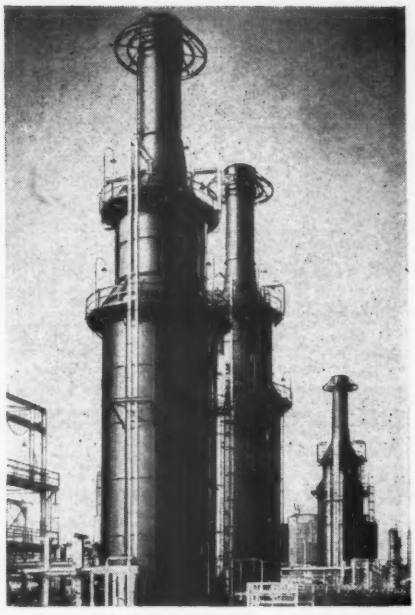

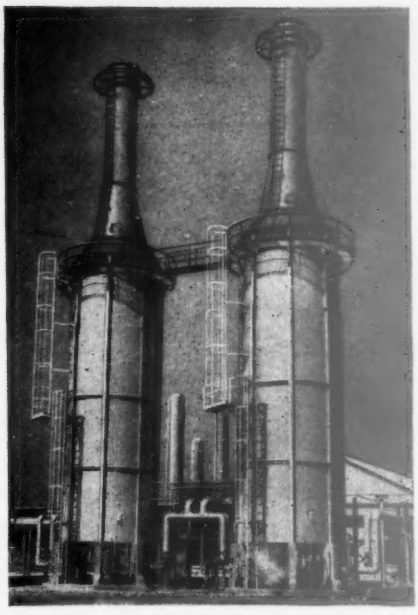

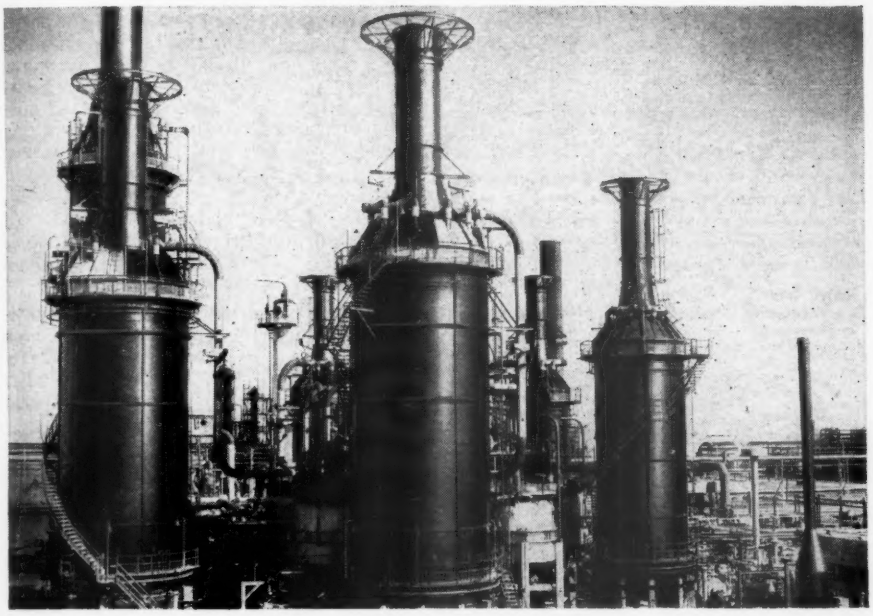

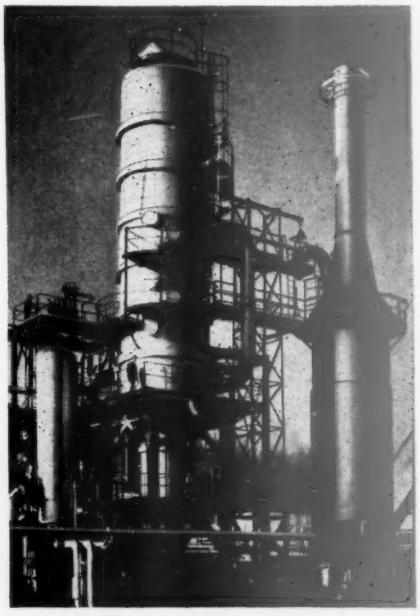

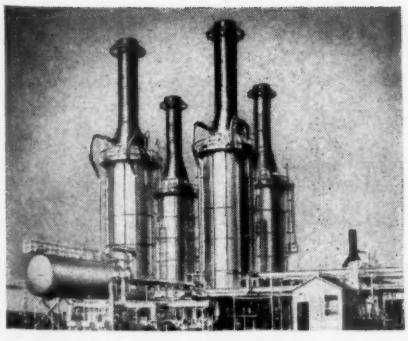

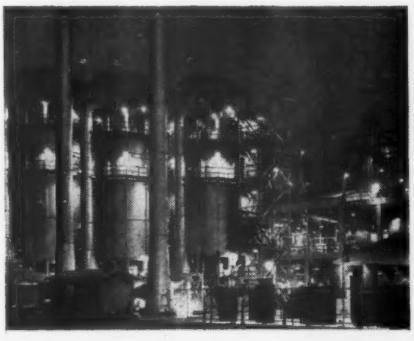

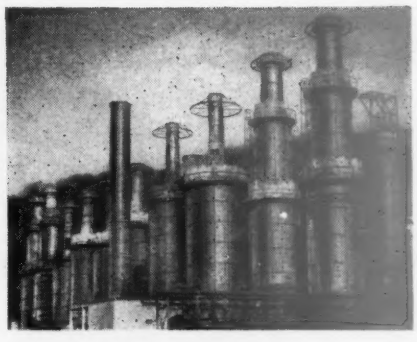

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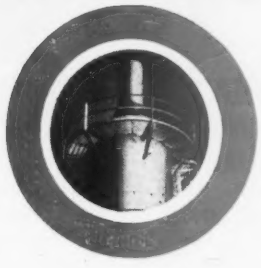


BOOKS ★

The Oil Resources of Texas, *by George H. Fancher with Robert L. Whiting and James H. Cretsinger, The Texas Petroleum Research Committee, Texas A and M College, College Station, Texas. Pages, 358.*

This survey of primary and secondary reserves of oil in Texas is an outgrowth of work performed by a group designated by the Texas Railroad Commission, Texas A and M College and the University of Texas in 1948. It includes a general summary of the oil production history, current (to 1952) production, and reserve strength of the 130,309 wells in 2369 oil fields, with tables, maps, historical data and summaries by individual oil producing districts and counties. The volume is particularly slanted toward secondary recovery reserve, of increasing meaning and consideration in the life expectancy of producing wells.

Geology and Mineral Deposits of Barstow Quadrangle, San Bernardino County, California, *Oliver E. Bowen, Jr., Bulletin 165 of the Bureau of Mines, Ferry Building, San Francisco 11, California. Pages, 208. Price, $3.00.*

The Barstow Quadrangle is an area of nearly a thousand square miles in the heart of California's Mojave Desert. It is a virtually untouched area of gold, silver, iron, copper, and tungsten ore, non-metallic resources such as limestone, magnesite, mica-quartz fillers, marble and granite. This cloth-bound bulletin contains pertinent information in the form of economic, geologic and outline geologic maps, as well as close-up and aerial photographs of all areas and structures. With the book are nine aerial photos and color maps of the Quadrangle.

Accompanying the main article and under the same cover is a paper entitled "Thermal Properties of Ceramic Materials from Barstow Quadrangle, California." It was prepared by Joseph A. Pask, professor of Ceramic Engineering at the University of California, in cooperation with author Bowen, and presents some laboratory tests of peculiar ceramic materials found in the area.

The Nation Looks at Its Resources, *Report of the Mid-Century Conference on Resources for the Future, Resources for the Future, Inc., 1145 19th Street, N. W., Washington, D. C. Pages, 418. Price, $5.00.*

This is a report of the Mid-Century Conference on Resources held in Washington, D. C., December 2-4, 1953. The chapters are introduced, then statements made by the various persons on the committee are condensed from the record. For an overall picture of U. S. resources this is an excellent description and reference. It represents the thinking of the 1600 men and women who explored and sought to relate issues that will be before the people of the United States during the next 25 years and beyond.

As related specifically to petroleum, John R. Suman of Standard Oil Company of New Jersey, was on the conference steering committee and one of the council sponsors was Frank M. Porter, president of the American Petroleum Institute. So far as describing present resources and how they are estimated, the volume is a good reference, although it does not go into detailed data. In trying to estimate future reserves, however, council members were under the same limitations as others who have tried to make this estimate. The point made by Serge Jurenev of Continental Oil Company indicates the reason for this: "Our resources are dynamic, not static. Prices, technology, and other factors are all involved, and effect the volume of reserves ultimately recoverable."

He Lived for Adventure, *by Campbell Osborn, Campbell Publishing Company, 330 Woodward Building Washington, D. C. Pages, 268.*

A book of travel, written in autobiographical style, the author carries the reader from the Oklahoma oil fields around the world, exploring many subjects and many vocations. It is a preliminary edition relating the experiences with noted government and military leaders and gives a good insight into the thinking and economic backgrounds of peoples from Bermuda to Burma, as seen through the eyes of this writer.

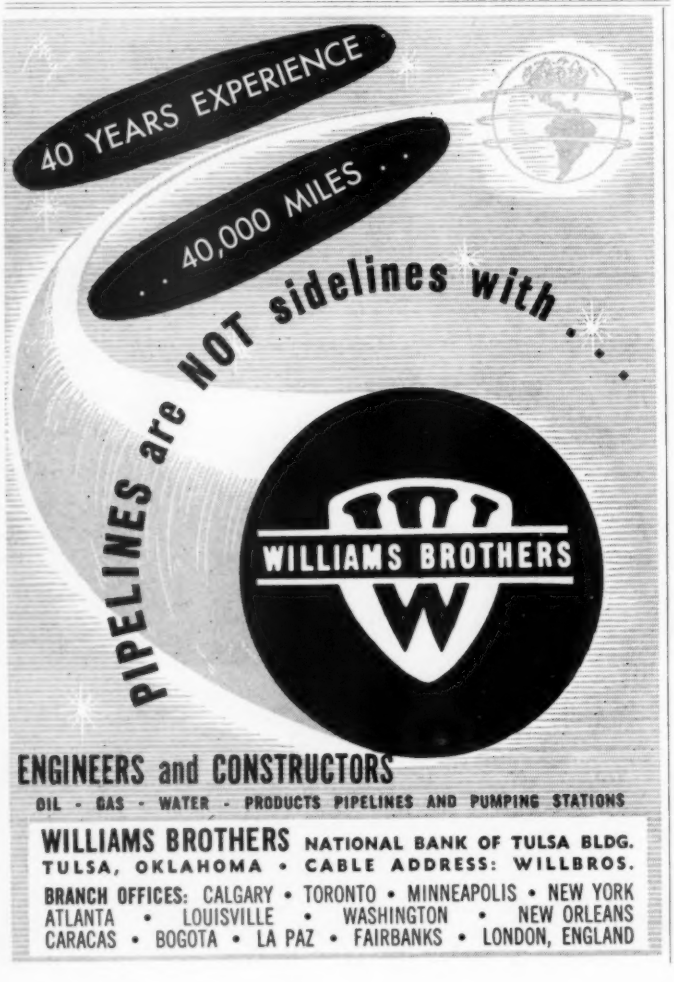
Catalysis, Volume 2; **Fundamental Principles** (Part 2), *edited by Paul H. Emmett, Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y. Pages, 473. Price, $12.00.*

As included in the earlier volume in this series, this book is concerned with the fundamental principles and theories of both hetergeneous and homogeneous catalysis. The new material presented, relative to catalyst supports and methods of catalyst preparation, is of the nature and mode of action of porous solid catalysts, well flanked by supporting tables.

In completing the series, presentation is made of the fundamental catalytic principles, and stresses the measurement of pore distribution; the influence of pore distribution on the kinetics, temperature coefficient, and specifically of reactions on solid catalysts, the nature of the catalyst surface, and finally, the general theories of heterogeneous catalysis. Duplication of subject matter between volumes and within volumes is kept to a careful minimum.

Contributing to this volume are a group of outstanding chemists, representing both industry and educational institutions, Henry Eyring, Hugh M. Hulburt, W. B. Innes, Edward L. King, Ransom B. Parlin, Merrill B. Wallenstein, Ahlborn Wheeler, and Bruno J. Zwolinski.

Volume 1 of this important series was reviewed in this column May, 1954.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No other Engineering-Constructor matches Stearns-Roger "know-how" in cold country design and construction. It pays to

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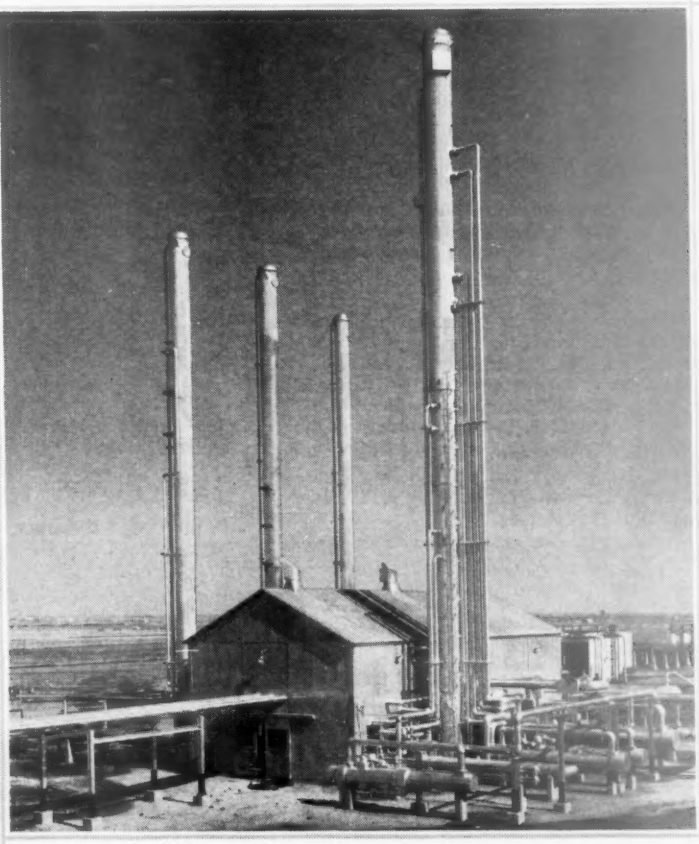
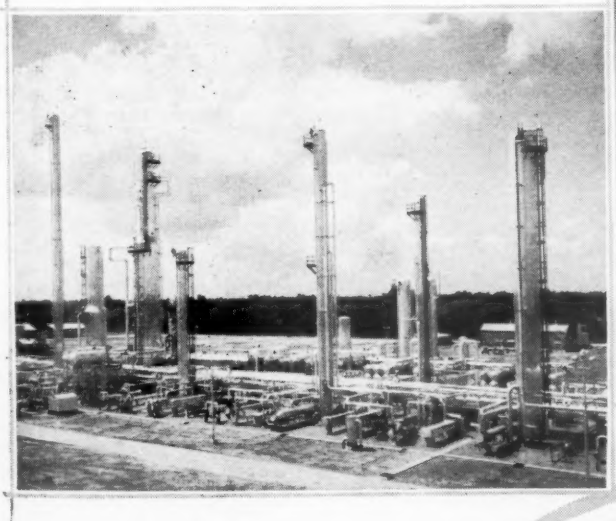
Two plants, recently put on stream, are examples of designing to conditions—by Stearns-Roger.

Plant for The Ohio Oil Company near Sydney, Nebraska. 12,000,000 cu. ft. of gas per day. Deep sub-zero temperatures anticipated. Steam power is eliminated to avoid water piping subject to freezing. All instrumentation and operating equipment fully enclosed in insulated building—kept small by special attention to space-saving design.

A Gulf Coast plant handling more than 200,000,000 cu. ft. of gas. In this instance, most of the equipment is placed out of doors to take advantage of the mild climate.





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LAUGH with BARNEY

The best man was not acquainted with the bride, so he introduced himself at the reception like this:

"I hardly feel like a stranger. When John and I were overseas together, he frequently read aloud portions of the letters from his darling Betty."

"Is that so?" the bride snapped, "my name happens to be Joan."

Again the young wife called her parents to report that her husband had left home after a quarrel.

"What of it," the father retorted, "he's done it before and he's always come back."

"But this time he took his golf clubs," the daughter wailed.

Personally, we say nuts to the cannibal who ate his father and mother and then, when arrested, pleaded for mercy because he was an orphan.

"Have you seen Myrtle's new evening gown?" "No, what does it look like?" "Well, in places it looks like Myrtle."

"I don't know what's the matter with that man over there. He was so attentive a few moments ago and now he won't even look at me." "Perhaps he saw me come in, he's my husband."

"Your husband looks like a brilliant man, I suppose he knows everything." "Don't be silly, he doesn't even suspect anything."

"The rate is $1.20 for three minutes," said the telephone operator, "and 30 cents for each additional minute." The caller said: "Do you take anything off for just listening, I want to call my wife."

"I can't marry him, Mother. He's an atheist. He doesn't believe in hell." "Marry him, dear—and between us we'll convince him he's wrong."

"Do you know that they don't hang men with wooden legs in China?"

"Zat so? Why?"

"They use rope."

A tavern owner, touring Switzerland, was climbing up a snow-covered mountain with a guide when they were caught in a snowslide. Eventually a St. Bernard dog pushed through to them, a keg of brandy tied under his chin. "Hurray," shouted the guide. "Here comes man's best friend."

"Yes," agreed the tavern owner, "and look at the size of the dog that's bringing it!"

Tailor (wrapping up suit): **You know, I'm letting you have this garment at less than it cost me to make it."**

Customer: **You're always telling me that. How do you make a living?"**

Tailor: **Oh, I make a small profit on the paper and string.**

Smart Alec Tourist: **What's your speed limit here?**

Native: **Ain't got none! You fellows can't go through here too fast for us.**

Husband to wife: What do you say we take this money we've been saving toward a new car and blow it on a movie?

A hypochondriac told his physician that he had a fatal liver condition. "Nonsense," said the doctor, "you wouldn't know whether you had that or not. With that condition there is no discomfort whatever."

"My symptoms exactly," said the man.

Mrs.: Strange how few of our youthful dreams come true.

Mr.: Oh, I don't know. When I was small I used to dream about wearing long pants. And now prices are so high I have to wear pants longer than anyone else on earth.

Hobo (to housewife): It isn't that I'm avoiding work, ma'am. There isn't much doing in my particular line. I'm a window box weeder.

Some girls seem to think the new bathing suits are indecent; others have attractive figures.

Two dogs were having a chat and one of them noticed the other was feeling awfully low. So he said to his friend, "Why don't you go see a psychiatrist?"

To which the other dog replied, "You know I'm not allowed on the couch."

Marriage is like a bath—by the time you get used to it, it's not so hot.

Conscience doesn't keep you from doing anything wrong, just keeps you from enjoying it.

The patient thought he was a dog. The psychiatrist worked on him for a month before treatment was completed. A friend met the patient on the street. "How do you feel?"

"Fine," said the man, "Feel my nose."

A sour-faced, oddly dressed lady poked among the brooms in a hardware store when a clerk asked if he could help her.

"Nothing's worth buying," she snapped. "Flimsy, cheap straw, poor handle, shoddy material." Seizing a broom, she shook it under the clerk's nose and said angrily: "Not like the brooms they used to make! Give the floor one good sweep and it would fall apart! What's it good for?"

"Well," the clerk said after a thoughtful pause, "you may find that it flies wonderfully."

Two neurotics nervously discussed their love affair. "Don't fight it," the boy begged his sweetheart. "This thing is buggier than both of us."

Now I lay me down to sleep,
The lecturer's dry, the subject's deep.
If he should quit before I wake,
Someone kick me, for goodness sake.

"Boy, oh boy! That was some blonde with you last night. Where did you find her?"

"Dunno. I just opened up my billfold and there she was."

The reason that God made woman after he made man, was because He didn't want any advice.

"Dad," asked the small boy, "why is a man allowed to have only one wife?"

"My son," replied the father, "when you are older you will realize tnat the law protects those incapable of protecting themselves."

Husband: If I'm unable to get back from this trip tonight, I'll send you a note.

Wife: Never mind, I found the note in your pocket last night.

An old man from the hill country took his first trip to a large city. Walking into one of the skyscrapers he saw a doorman standing by a special kind of a door. An old lady stepped in, a light flashed red and she was gone. A moment later the elevator descended, the door opened and out stepped a beautiful young girl.

"Begorra," said the old man, blinking his eyes, "I should have brought the old woman with me."

The collection department of a Chicago firm tried a new method on a slow-paying account.

"Dear Mrs. Smith," the letter began, "what would all your neighbors think if we came to your town and repossessed your car?"

In time the latter came back with a message scrawled at the bottom. "I have taken up this matter with my neighbors," it said, "and they think it would be a lousy trick."

The best way to get a job done is to give it to a busy man. He'll have his secretary do it.

A husband makes his worst mistake not so much in forgetting his wife's birthday, as in remembering her age.

We hear that statisticians find that nine out of ten women are knock-kneed. And for years we'd been thinking that statisticians never had any fun!

"Sorry to hear about the death of your uncle," the friend consoled, "what was the trouble?"

"It was peculiar," the nephew admitted. "It seemed that the old man had a prolonged backache. Finally, the doctor rubbed it with alcohol, and my uncle broke his neck trying to lick it off."

Courtship—the period during which a girl decides whether or not she can do any better.

"Was your uncle's mind vigorous and sane up to the very last?"

"We don't know yet. His will won't be read until next week."

There isn't anything upsets a woman quite so much as having company drop in to see the house looking as it usually does.

French lawyer pleading for an attractive transgressor: "Gentlemen of the jury. Shall this charming young lady be cast into a lonely cell, or shall she return to her beautiful little apartment at 33 Rue Neuve, Telephone 883954?"

Policeman: **How did you knock him down?**

Motorist: **I didn't. I pulled up to let him go across—and he fainted.**

OIL and GAS TRADE NEWS

Brazilian Contract Awarded

Southwestern Engineering Company, Los Angeles, California, has been awarded a major engineering assignment in Brazil. The contract calls for design and erection supervision for an asphalt plant and crude terminal facilities for Petroleo Brasileiro, S. A. Project is scheduled for completion in November.

Pacific Coast Borax Opens Office

Pacific Coast Borax Company, division of Borax Consolidated, Limited, has opened a new district sales office in Kansas City, Missouri. This office will serve three divisions of the company, namely, package, agricultural sales, and industrial sales.

Youngstown Employees Graduate

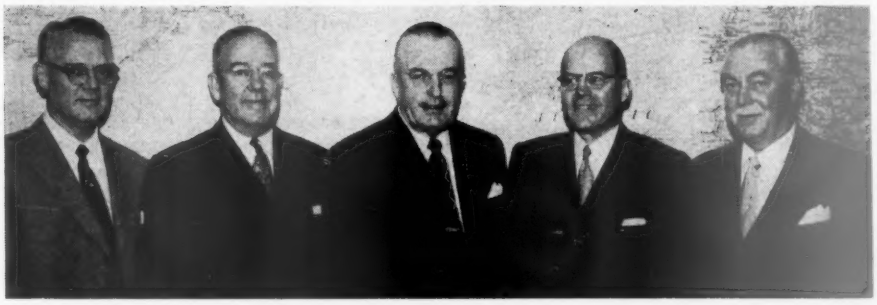
More than 450 employees of The Youngstown Sheet and Tube Company have graduated from the company's economic education program. Certificates were presented at banquet dinners. The graduates have completed 15, two-hour sessions on "How America's Economic System Operates," taught by Paul W. Schumacher, instructor.

Caterpillar in Australia

Formation of Caterpillar of Australia Pty. Ltd., a wholly-owned subsidiary, has been announced by Caterpillar Tractor Company. The subsidiary, third foreign company formed by Caterpillar since 1950, will manufacture and sell many of the regular products now built by the parent company, as well as replacement parts for the entire line of caterpillar products.

Representative Named

The Cleaver-Brooks Company has appointed the Delval Equipment Corporation, Philadelphia, Pennsylvania, as manufacturers' representative for the sale of Cleaver-Brooks boilers and equipment.



Lane-Wells Company and Dresser Industries, Inc., executives are pictured at meeting where Lane-Wells stockholders voted to become one of Dresser Industries. They are John J. Neale, president, Lane-Wells; Walter T. Wells, founder-chairman; Rodney S. Durkee, chairman of the board; H. N. Mallon, president, Dresser Industries, and J. B. O'Connor, executive vice president, Dresser.

Subsidiary Added

Acquisition of Brooks Equipment and Manufacturing Company by the Ingersoll Kalamazoo, (Michigan), division of Borg-Warner Corporation has been announced. The Brooks company will be operated as a subsidiary of Borg-Warner. President of the new subsidiary will be J. H. Ingersoll, who also is president of the Ingersoll Kalamazoo Products, and Ingersoll Conditioned Air divisions of Borg-Warner. R. F. Schultz has been named vice president of Brooks.

Safety Record Set

One-hundred and seven separate employee groups of the Lone Star Gas Company and its wholly-owned subsidiary, Lone Star Producing Company, have attained perfect safety records representing 19,169,199 (million) hours of work without a lost-time accident. The records, ranging from one through 26 years as of December 31, 1954, represent a cumulative total of 457 years. A. W. Breeland, Dallas, heads the safety program.

Stuber Saran Representative

Herbert D. Stuber, formerly superintendent of The Dow Chemical Company's saran rubber department, has opened an office in Indianapolis to represent Saran Lined Pipe Company of Ferndale, Michigan, in a territory including Indiana, Kentucky and parts of Ohio and Illinois.

Chain Belt Buys Land

Chain Belt Company, Milwaukee, Wisconsin, has purchased 47 acres near Downers Grove, Illinois, for the purpose of expanding its Shafer bearing division manufacturing facilities. Shafer was acquired by Chain Belt in 1953.

Graver Names Representative

Graver Water Conditioning Company, New York, has appointed the Frontier Engineering Services Company, Salt Lake City, Utah, as new representatives. Their organization's territory consists of the northern and western parts of Wyoming, most of Nevada and all of Utah.

Houston Oil Field Material Company personnel are shown on a recent visit to the home offices and plants of Wheland Company, Chattanooga, Tennessee. The group toured all three of Wheland's Chattanooga plants. HOMCO distributes Wheland's rotary drilling equipment. The men are Otho Meadows, Jack Watson, George Haltom, Harris Lodge, Joe Seale, D. B. Allison, purchasing agent; Bill Widdon, George Bean, Lynn Bell, sales manager; Cecil Hayes and Gordon Smith, Jr., right, are Wheland representatives.

XUM

J. F. Pritchard and Company sales representatives and company officials are shown at annual sales meeting in Kansas City. Front row: S. K. Walling, The Walling Company; G. T. Miller, Burson Sales; W. R. Roeyer, sales manager; T. F. Killeen, T. F. Killeen Company; Walter Locke, Thermecon, Inc.; I. A. Hoekstra, Killeen; A. H. Stroyd, Bristal Metals Products; Fred Richeda, The Lang Company. Second row: Carl Cutright, Y. C. Smith and Company; Vance A. Morrow, Hoffman and Hoffman Company; B. E. Anderson; Don McRae, Rittlemeyer and Company; J. L. Brownlee, Brownlee-Morrow Engineering; J. I. Marquard, Northwestern Power Equipment; W. M. Hawkins, Bristal. Third row: Neil W. Kelly; C. N. Fulcher, The Fulcher Company; L. C. Sandy; Louis Loeffler, Jr., Federal Sales Engineer; R. J. Stewart, J. F. Pritchard and Company; Randall S. Stover, Randall S. Stover Company; Morley Hudson, Hudson-Rush; Don Landry, Factory Sales and Engineering, Inc.; Jack Rush, Hudson-Rush; W. R. Johnson, Federal Sales Engineers; L. W. Edelmann, Northwestern Power; P. A. Frohwerk. Fourth row: G. E. Koutelas, Pritchard; Frank Rucker; Norman A. Brown, Wilcox Engineering; E. A. Quaglia, Pritchard; B. B. Farmer, T-1 Equipment, Inc.; Paul Bower, Pritchard. Fifth row: Carl V. Spangler, Pritchard; R. A. Walling, The Walling Company; R. R. Derber, Robert R. Derber Company; R. E. Bradley; J. F. Pritchard, president; P. S. Lyon, secretary-treasurer; Max A. Teale; C. F. Shortal; H. Arthur Martin, vice president; Karl E. Johnson, all of Pritchard.

Homco to Open Store

Houston Oil Field Material Company, Inc., will open a new sales and service tool store in Sherman, Texas, to serve the North Texas and Southern Oklahoma area. J. O. "Bill" Redmon will be in charge of services in that area.

Tuboscope Adds Annex

Tuboscope Company has recently completed and occupied a new executive annex to the main plant at Houston, Texas. The annex contains 3800 sq ft of space including a large reception room, conference room and 6 large offices.

Reed's Export Office Moves

Export offices of the Reed Roller Bit Company, oil well drilling tool manufacture, have been moved to Suite 1011, International Building, 45 Rockefeller Plaza, in New York City. Reed's export office was formerly at 1836 RCA Building.

The PELICAN

THE Lowest PRICED TWO-INCH PUMP OF ITS CAPACITY ON THE MARKET

Gorman-Rupp self-priming centrifugal pumps are especially designed to meet the toughest requirements. The Pelican has many useful applications around a lease and -- it challenges any pump its size and type to equal its performance -- it never quits.

Gorman-Rupp pumps are the **Quickest Priming, Highest Priming, Fastest Pumping** and **Most Reliable** pumps available.

There's a choice of four lightweights for any requirements:

The Midget 1½"	Weight 62 lbs.	. . .	5500 G.P.H.
The Pelican 2"	Weight 70 lbs.	. . .	7500 G.P.H.
The Hawk 2"	Weight 110 lbs.	. . .	10,000 G.P.H.
The Eagle 3"	Weight 117 lbs.	. . .	18,000 G.P.H.

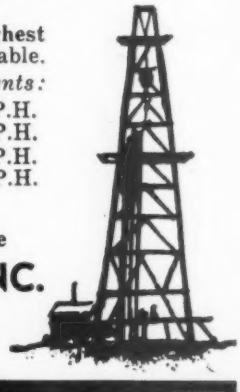
Ask for Bulletin No. 7-LW-13

Mid-Continent and Gulf Coast Oilfield Representative

HENRY H. PARIS DISTRIBUTOR, INC.

1125 Rothwell Street, Houston, Texas

A COMPLETE LINE OF CENTRIFUGALS IS AVAILABLE UP TO 240,000 G.P.H. CAPACITY.



THE GORMAN-RUPP COMPANY

MANSFIELD, OHIO

CARBON-BAKELITE PISTON RINGS

. . HIGHEST EFFICIENCY WITH LEAST WEAR!

For your gas compressors, you need a highly effective, low friction material not affected by wet or sour gases.

FRANCE MAKES THEM!

Write for Complete Information

FRANCE PACKING COMPANY

9926 Bustleton Ave., Philadelphia 15, Pa.

Latest advances in Blue Demon rock cutter and insert rock bits were displayed at the Rocky Mountain AAPG meeting, Billings, Montana, by sales executives of Herb J. Hawthorne, Inc. They are Charles T. Baker, Mid-Continent division sales manager, Oklahoma City; C. Max Fountain, Rocky Mountain division sales manager, Denver, Colorado; and Earl M. Weaver, general sales manager, Houston, Texas.

Great Lakes Names Representative

Great Lakes Corporation has appointed Mud Control Laboratories, Inc., as its sales representative in the Rocky Mountain area.

Honeywell Opens Office

A new branch sales and engineering service office in Hammond, Indiana, has been opened by Minneapolis-Honeywell Regulator Company. O. V. Spousta will manage the new office, which will handle the sale, design, service and installation of automatic temperature controls and industrial processing systems in the southern portions of Cook and DuPage counties, in four other eastern Illinois counties and in two counties in Indiana.

First Order Shipped

The first order of National plastic pipe manufactured at the Gary, Indiana, plant of United States Steel Corporation's national tube division has been shipped. Construction of the Gary plastic pipe plant began in June of 1954 and production was started the first of October.

Steel Pipe Plant Operating

The Consolidated Western Steel division of United States Steel Corporation began production of large diameter, high strength expanded line pipe in early April at its new steel pipe manufacturing plant near Provo, Utah. Described as the most modern expanded pipe mill in the West, the plant has been under construction since October 1, 1954.

Girdler Completes Expansion

The Girdler Company, Louisville, Kentucky—a division of the National Cylinder Gas Company—has completed a second construction contract awarded by the nitrogen division of the Allied Chemical & Dye Corporation in a formaldehyde and urea expansion program at South Point, Ohio.

Bethlehem Plans Welded Pipe

Bethlehem Steel Company's $200,000,000 two-year expansion program will include the installation at Steelton plant of equipment for the fabrication of welded pipe, expanded hydraulically to increase its strength approximately 25 per cent.

Seamless Pipe Shipped

Shipment of the first commercial order for a new product—cold expanded seamless pipe—has been made from the Lorain Works of U. S. Steel Corporation's National Tube division. The pipe will be used in the construction of a 24-in. gas transmission line that will extend across 250 miles of densely populated areas in the Eastern United States.

Lone Star Names Mid-Continent

The appointment of Mid-Continent Supply Company as distributor for Lone Star Steel Company oil country tubular goods has recently been announced. This follows earlier appointments of Bovaird Supply Company and United Supply and Manufacturing Company.

Coke for Industry

Successful use of fluid petroleum coke as a fuel in an industrial plant operating at full capacity has been announced by Kaiser engineers division of Henry J. Kaiser Company. The recent test was made during kiln firing at the Permanente Cement Company's plant at Permanente, California. Normal production operations were reported to be neither interrupted nor reduced when the fluid coke was injected into the fuel system.

Dewey in New Office

The Dewey Supply Company, Tulsa, Oklahoma, has announced the opening of new offices in the Constantine Building, 611 S. Boston, in Tulsa.

ARCCO
LIQUID GRAVITOMETERS
NOW 19 MODELS
MODEL RES
ARCCO—Anubis
For RECORDING, SIGNALLING
TRANSMITTING and CONTROLLING
For pipelines, refineries, chemical plants, etc., ARCCO Anubis Liquid Gravitometers are ruggedly built for hard field usage yet are accurate in performance as a laboratory instrument.
Temperature corrected, these extremely accurate instruments are adaptable to high pressures and are available with internal parts suitable for practically all corrosive liquids.
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3113 E. 11th St. • Los Angeles 23, Calif.
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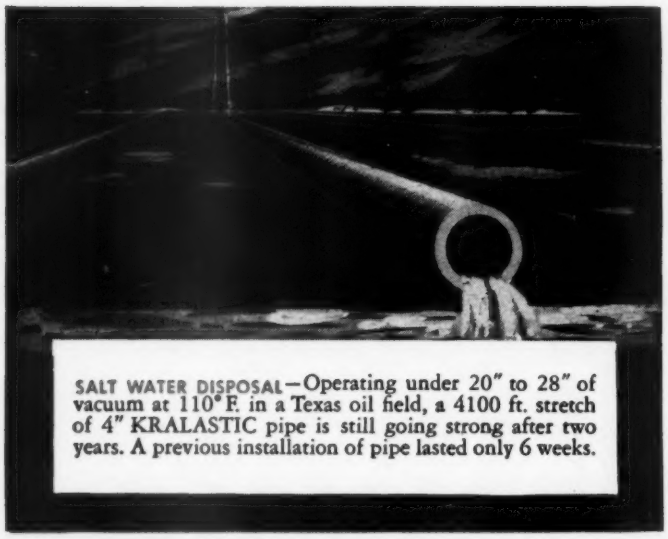
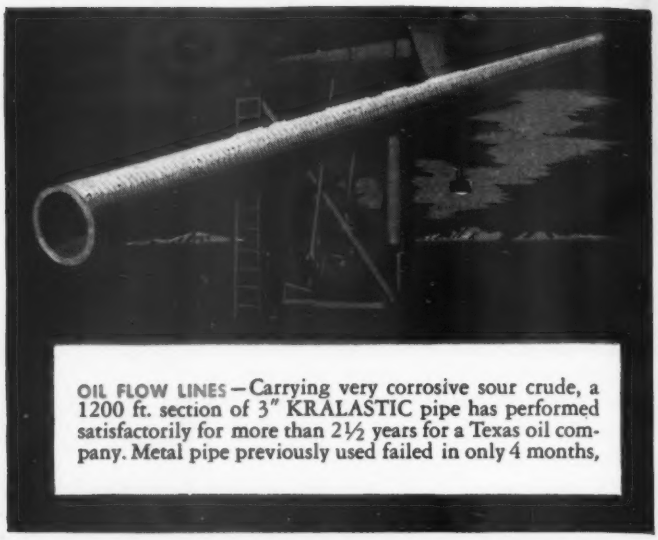
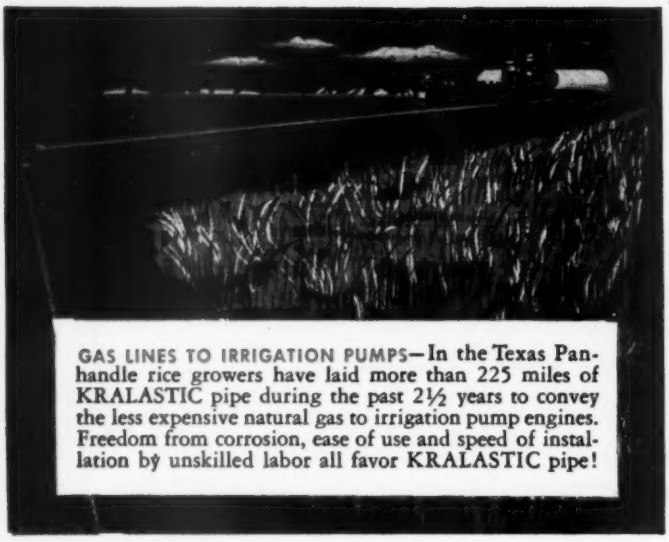
KRALASTIC Corrosion-Proof Pipe Makes Good in Many Fields!



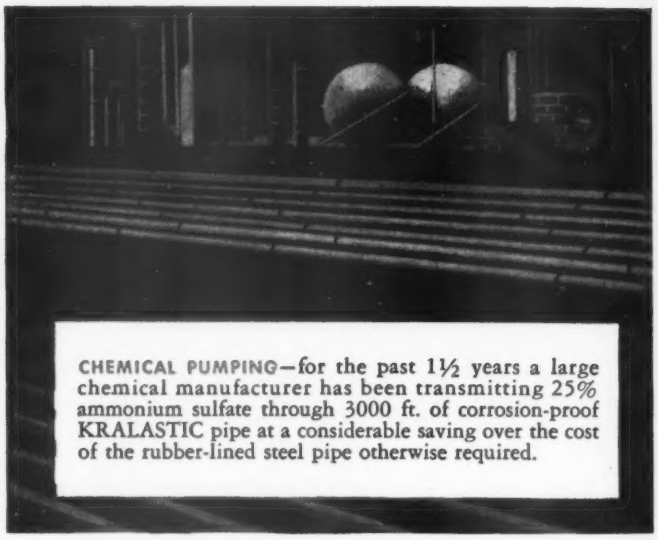
SALT WATER DISPOSAL—Operating under 20" to 28" of vacuum at 110° F. in a Texas oil field, a 4100 ft. stretch of 4" KRALASTIC pipe is still going strong after two years. A previous installation of pipe lasted only 6 weeks.



OIL FLOW LINES—Carrying very corrosive sour crude, a 1200 ft. section of 3" KRALASTIC pipe has performed satisfactorily for more than 2½ years for a Texas oil company. Metal pipe previously used failed in only 4 months,



GAS LINES TO IRRIGATION PUMPS—In the Texas Panhandle rice growers have laid more than 225 miles of KRALASTIC pipe during the past 2½ years to convey the less expensive natural gas to irrigation pump engines. Freedom from corrosion, ease of use and speed of installation by unskilled labor all favor KRALASTIC pipe!



CHEMICAL PUMPING—for the past 1½ years a large chemical manufacturer has been transmitting 25% ammonium sulfate through 3000 ft. of corrosion-proof KRALASTIC pipe at a considerable saving over the cost of the rubber-lined steel pipe otherwise required.

KRALASTIC pipe is made from a unique combination of plastic and elastomeric materials. It is different both in composition and characteristics from materials used in other types of plastic pipe.

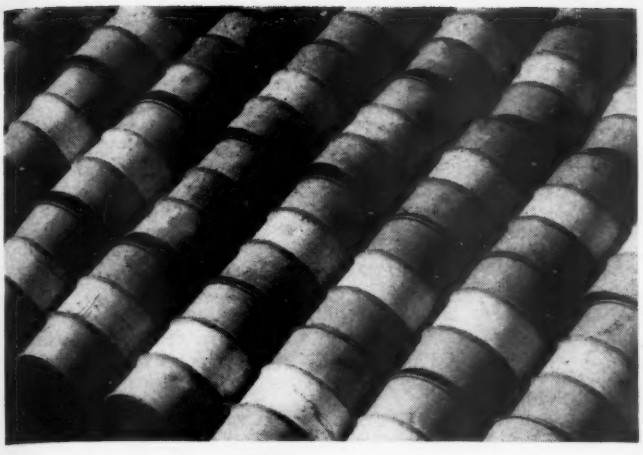
KRALASTIC produces pipe and pipe fittings that are both hard and tough, low in weight, high in tensile strength and unaffected by most chemicals that corrode metals.

KRALASTIC pipe is easily sawed and solvent-welded, or threaded for connection to metal fittings. Be sure the plastic pipe you buy is KRALASTIC. Write us for the names of firms making KRALASTIC® pipe.

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N.Y.



ONLY 7 MINUTES

to make drums good as new!

That's right! Used drums restored to like-new condition... cleaned, paint-stripped, rinsed, dried, and repainted—in just 7 minutes! That's how fast Oakite cleaning works in one barrel-house.

Here are just a few of the many BIG advantages that are yours when you recondition barrels and drums the modern Oakite way:

- Fewer rejects
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- Better adhesion for new paints
- No paint build-up on steam coils
- No clogging of drains and sewers

For further information on how to step up your drum conditioning operation, ask your local Oakite Petroleum Service Representative for a **FREE** copy of this comprehensive Oakite petroleum cleaning handbook. Or write Oakite Products, Inc., 48 Rector Street, New York 6, N. Y.

Technical Service Representatives in Principal Cities of U. S. and Canada

OAKITE

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PETROLEUM SERVICE DIVISION

Mobile 11-S does on-the-spot mixing

Combining heavy-duty strength with smooth-trailing mobility, Kwik-Mix 11-S Dandie® is the handiest concrete mixer you've ever seen for scattered oil field jobs. As a 2-wheel mixer, mounted on heavy coil springs — or as a 4-wheel mixer with automotive-type steering on front axle, this mobile 11-S is quickly towed over highways or back-country roads. It does on-the-spot mixing anywhere you need concrete — at drill sites, booster stations, around yards, refineries.

You get a consistent-quality mix, batch after batch, because double-mixing action of exclusive blade-and-bucket drum thoroughly cement-coats every particle of aggregate. Automatic water system accurately measures exact amount of water needed for each batch. A Batchmeter automatically controls the mixing time. Tilted Flow-Line chute discharges full batch in as little as 7 seconds.

You'll also like the wide, fast-charging skip, selective skip-shaker, smooth power-flow, fully enclosed gearing, multiple V-belt drive, and many other heavy-duty features you get with this 11-S Dandie mixer. Get all the details from your Kwik-Mix distributor, or write us. Other sizes: 3½-S to 16-S.

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Send us bulletins on: ☐ 3½-S ☐ 6-S ☐ 11-S ☐ 16-S concrete mixers

NAME..... TITLE.....

COMPANY..... DIV.....

STREET.....

CITY..... STATE.....

KM564 PE

(Koehring Subsidiary)

TRADE PERSONALS

Leland Strouse

J. L. Orr

Lee Croger

▸ **Leland "Pelie" Strouse,** vice president of Franklin Supply Company in charge of the Rocky Mountain-Western Canada area, has moved to new offices in the Denver Club Building, Denver, Colorado. **Don Davis** is in charge of Denver sales.

John L. "Jack" Orr, formerly with the Chicago sales office, has been placed in charge of the New York City office.

Lee Croger has been appointed manager of the company's new store in Morgan City, Louisiana.

▸ Scovill Manufacturing Company has announced organizational changes in the main plant operations. **Arthur M. Rogers,** formerly assistant to the vice president in charge of manufacturing sales, and **George A. Goss, Jr.,** formerly budget director of the manufacturing department, became assistants to **Arthur P. Hickcox,** president and general manager. **Ernest F. Rumberg,** asssistant planning director, has been named director of planning, succeeding **John B. Goss** who resigned because of ill health.

▸ Appointment of **Dr. E. W. Volkmann** as manager, research department, of Koppers Company, Inc., has been announced. He will be responsible for the coordination of all Koppers research.

▸ **Ralph A. Reynolds** has been appointed assistant treasurer of The Thew Shovel Company, Lorain, Ohio, after 35 years of service with the company.

▸ **Henry L. Charlton** has been appointed assistant to the president in charge of sales and manufacturing for Phoenix Manufacturing Company.

▸ **Roy H. Olson** has been appointed director of engineering in the communications and electronics division of Motorola, Inc.

▸ **R. A. "Bud" Darling** and **Melvin S. "Mel" Kenady** have established Darling-Kenady Company, manufacturers representatives specializing in oil industry equipment in Denver, Colorado.

▸ **L. M. Bracewell, Jr.,** has been appointed special salesman for Security Engineering Company's Gulf Coast division.
division, Dresser Operations, Inc.

▸ **Phil Norton** has been appointed executive vice president of Wisconsin Motor Corporation, Milwaukee, Wisconsin.

▸ **J. B. Sewell** has been elected a vice president of The Garlock Packing Company, Palmyra, New York.

▸ **C. Spence Purnell,** sales executive for the Westinghouse Electric Corporation in New York City for many years, has been named manager of the company's South Pacific district, headquartered in Los Angeles, California.

▸ **Aloysius M. Tullo,** works manager of Worthington Corporation's works in Harrison, New Jersey, has been appointed general manager of a newly established division to be known as the Harrison division.

Clarence K. Hood, a Worthington vice president, will be division sales manager; **George F. Habach** will be executive engineer; **Max A. Heyman,** Harrison works manager; **Thomas F. Quinlan,** division comptroller; and **Charles Schwalje,** foundry manager.

▸ Fluid Packed Pump Company has announced promotions of sales executives. **Glen W. Peters,** veteran salesman, who has served the company in various capacities since 1941, has been appointed assistant vice president and acting manager of the Southwest division. **D. H. Vandenberg,** formerly manager of the southwest division, has been appointed manager of product sales.

L. P. Chinn

▸ **Lloyd P. Chinn** has been transferred to field sales for Tex-Tube, Inc. He covers parts of the Houston area, East Texas, and Northern Louisiana. Chinn has been office manager supervising inside sales work for the company for the past three years. Prior to his work with Tex-Tube, Chinn was associated with Texas Pipe Bending Company and Maintenance Engineering Company in Houston.

▸ **Gordon F. McLaughlin, Sr.,** has been appointed a salesman for Welex Jet Services, Inc., in Pharr, Texas. **Clair E. "Moon" Mullins** has been appointed manager of the new service office in Winfield, Kansas. **C. T. Patten** has been named district manager for the Welex service office in Falfurrias, Texas.

B. B. McKnight has been appointed sales engineer for the Welex Jet Services district in Great Bend, Kansas.

▸ **E. G. Gilliland** has returned to selling for Industrial Chemical Company at Los Angeles, California. He was absent for a year because of illness.

▸ **Dr. Ernest H. Koeph** has been named manager of the research and development department of Core Laboratories, Inc., Dallas, Texas.

▸ **Robert J. Prudhomme** has been appointed as district engineer-compressor and engine sales, for the Oil Well Supply Division of U. S. Steel Corporation.

M. L. Childress has been named district representative at Carmi, Illinois. **William G. Smith, Jr.,** was appointed assistant manager at Olney, Illinois.

International visitors attending the Houston, Texas, Nomads' meeting were: H. K. Edwards, Texas Petroleum, Caracas, Venezuela; D. D. Lewis, Import Company, Ltd., Calgary, Canada; Henry W. Pullman, Baker Oil Tools, Inc., Los Angeles, California; V. W. Fletcher, Asiatic Petroleum, New York; Don H. Manson, Asiatic Petroleum, Houston; H. Bevan, Texas Petroleum, Bogota, Colombia; Gus A. Standish, Colombian Petroleum, Cucuta, Colombia; Benjamin Sodre, MAQUIP, Rio de Janeiro, Brazil, and Giuseppe D'Auria, Montecatini Company, Milan, Italy

▸ **A. E. (Bud) Hess,** who joined General Controls Company of Glendale, California, as a sales engineer in March of 1944, has been appointed southwest regional manager with headquarters in Dallas, Texas.

▸ **Max I. Alimansky** has been named general manager of the General Electric Company's rectifier department, Lynn, Massachusetts. He succeeded **William J. Fleming,** who has been granted a leave of absence.

▸ **William L. Wolfe** has been appointed vice president, sales, of Jones & Laughlin Steel Corporation's supply division.

▸ **Sam F. Holmes, Jr.,** has been appointed assistant director of advertising and public relations for the First National Bank in Dallas, Texas.

▸ Enterprise Engine & Machinery Company, subsidiary of General Metals Corporation of San Francisco, California, has appointed **Max Knopp** to the position of export manager.

▸ **Robert J. Stoup,** plant metallurgical engineer at the Ambridge, Pennsylvania, plant, Spang-Chalfant division of The National Supply Company, has been appointed assistant chief field engineer, with headquarters at Tulsa, Oklahoma.

The UNDERWRITER. . . . .

. . . a specialist in WORKMEN'S COMPENSATION INSURANCE

The TEIA Underwriter is a specialist in Workmen's Compensation Insurance, with a thorough understanding of the employer's problems and the special provisions of the Texas Workmen's Compensation Law.

Let the TEIA Underwriter and the SERVICE TEAM, of which he is a part, work with you . . . to improve your Workmen's Compensation Insurance coverage and service . . . and SAVE you money.

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HOMER R. MITCHELL, *Chairman of the Board* A. F. ALLEN, *President*

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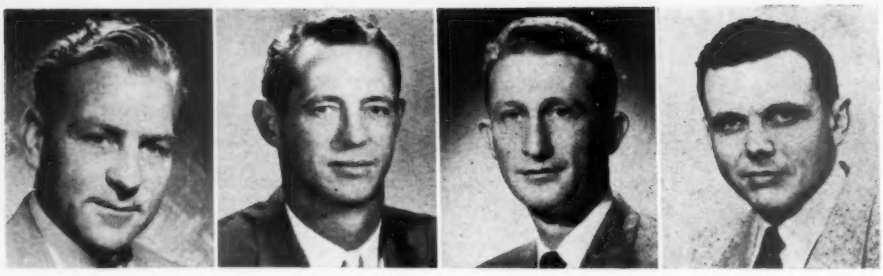
TEXAS EMPLOYERS INSURANCE ASSOCIATION
HOME OFFICE · DALLAS, TEXAS

Trade Personals



W. D. Willes J. L. Vint, Jr. C. E. Mays R. W. Negus

▸ **W. D. Willes,** former general manager of Rockwell Manufacturing Company's Nordstrom valve plants, has been named product manager, Nordstrom valves, with headquarters at Pittsburgh.

▸ Franks Manufacturing Corporation of Tulsa, Oklahoma, has announced personnel changes to mark the beginning of a division of its sales and service force. **K. M. Lamer,** a 13-year veteran with Franks will fill the post of assistant sales manager at Tulsa. **W. G. "Bill" Pitezel,** also a 13-year veteran will take over Lamer's former position in Odessa as West Texas district sales manager. **Louis Sears** becomes West Texas district service manager, and **Albert Wagner** will be parts manager in the Odessa office. Pitezel's former position as Oklahoma district sales manager will be filled by **J. G. Leyh,** who joined Franks in 1940, and who has been Franks used equipment manager. **Joe S. Winter** will take over as service manager for west coast operations to be located at Compton.

▸ **N. H. Ottinger** has been appointed to the recently created position of division logging engineer for McCullough Tool Company's Mountain division.

A Zoologist Writes: "Every imaginable remedy tried for protection against ticks and chiggers; only Ticks-Off passed the acid test."

STOP INSECT BITES!
PREVENT DISEASE & INFECTION!

TICKS-OFF

More Than A Repellent

SAFE! FAST! Keeps away Chiggers, Ticks, Mosquitoes, Flies. A few second spray protects you all day!

12 Oz. Bombs

Do you know that biting ticks transmit to humans twice the number of tularemia cases than handling or skinning of rabbits.

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MINE SAFETY APPLIANCES CO.
201 North Braddock Avenue
Pittsburgh 8, Pa.
76 Branch Offices in the United States

▸ **J. L. Vint, Jr.,** has assumed new duties as vice president of sales for Unit Rig and Equipment Company. Formerly vice president of engineering, he succeeded **J. T. Tucker.**

▸ Houston Oil Field Material Co., Inc., has announced a number of personnel transfers and promotions. **Donald Erskine** has been promoted at Sullivan City, Texas, to manager of the Homco store there. **W. S. George** is now doing telephone sales in the Houston offices of Homco. **Richard Morgan** is now a field salesman at Odessa, Texas. **J. W. Clampitte** has been transferred to the directional drilling department in Houston.

In Odessa **F. E. Sandefer** has been promoted to field representative. **Frank Singletary** has been transferred to Corpus Christi as directional drilling superintendent of the Southwest Texas area.

▸ The Frank G. Hough Company, Libertyville, Illinois, has promoted **G. A. Gilbertson** and **R. L. Beverstedt** to executive vice presidents. Gilbertson, formerly vice president in charge of sales, advertising and service, is now executive vice president and general manager. Beverstedt, formerly vice president and chief engineer, is now executive vice president in charge of engineering and product development.

▸ Dravo Corporation has announced the appointment of **H. W. North** as chief engineer of the newly-established process equipment department of its engineering works division.

▸ Eight field and headquarters promotions and transfers have been announced by Schlumberger Well Surveying Corporation. **E. A. Colle** has been named assistant to the area manager, New Orleans, Louisiana. **J. J. Maricelli** is now assistant manager of the South Louisiana division, Gretna. **John R. Peasley** has been transferred to the technical staff of the operations department at Houston. **Vance E. Moss** replaced Peasely at Mt. Carmel.

C. R. Miller has been transferred to Wichita, Kansas, as assistant division manager. **C. B. Evans** has been named assistant to the division manager at Oklahoma City. **Guy Sullaway** has been transferred to assistant to the division manager, Gulf Coast division in Houston. He has been replaced at Cushing by **G. H. Morris,** formerly location manager at Russell Kansas.

▸ **H. H. Reed,** district manager of the Metropolitan district, New York, for Air Reduction Sales Company, was appointed national accounts manager.

▸ **Jim Whitaker** has been named special representative for Christensen Diamond Products Company with offices in Denver, Colorado. **Hugh Gunn** has been advanced to division manager.

▸ **C. E. Mays** has returned to Anaco, Venezuela, where he is in active charge of The Parkersburg Rig and Reel Company's sales activities in South America.

▸ **S. C. Danforth** has been promoted to sales promotion manager of Arnold O. Beckman, Inc., **Robert W. Negus** heads the new custom products department.

▸ Leland Equipment Company has announced the addition of five new salesmen. **Philip B. Davidson, G. R. "Deac" Werner, Burton Dicks, Thomas A. Robertson** and **Claude J. White** have joined the company to handle truck body and construction equipment sales throughout the Mid-Continent and surrounding state area.

Leland also announced that **R. L. McGrew,** sales engineer for Chicago Pneumatic, has established his personal headquarters in the Leland Building at 408 North Main Street in Tulsa.

▸ **Garland B. Childers,** staff engineer for Johns-Manville in the San Francisco district, has been appointed the newly established position of general construction superintendent of the company's industrial products division with headquarters at New York City.

▸ **Bradlee Pruden** has been elected vice president in charge of engineering at RicwiL, Incorporated, Barberton, Ohio.

▸ **Emerson G. Gaylord** has been re-elected chairman of the board of The Chapman Valve Manufacturing Company. **Earnest Cochran** was re-elected president of th company. **David M. McIntosh,** was elected executive vice president and was re-appointed vice president in charge of production. **Joseph A. Cerow** was re-appointed vice president in charge of engineering. **Frank A. Hunter** was appointed vice president in charge of sales. **A. Neilson Cochran** was re-appointed assistant treasurer and assistant clerk.

▸ **Waldo McC. McKee** has been appointed sales manager of the fabricated products division of The M. W. Kellogg Company.

▸ Otis Pressure Control, Inc., has appointed two new division managers. **Warner M. Kelly,** formerly South Texas division manager of the caliper department, has been named South Texas division manager, and **Bill T. Mitchell,** former Southern Louisiana division superintendent, has been promoted to manager of the West Texas division.

Otis has named **Jack R. Russell** as its sales engineer in the West Texas-New Mexico area, with headquarters in Hobbs.

▸ The Ramo-Wooldridge Corporation, Los Angeles, California, has appointed **Dr. David B. Langmuir** to the staff of its guided missile research division.

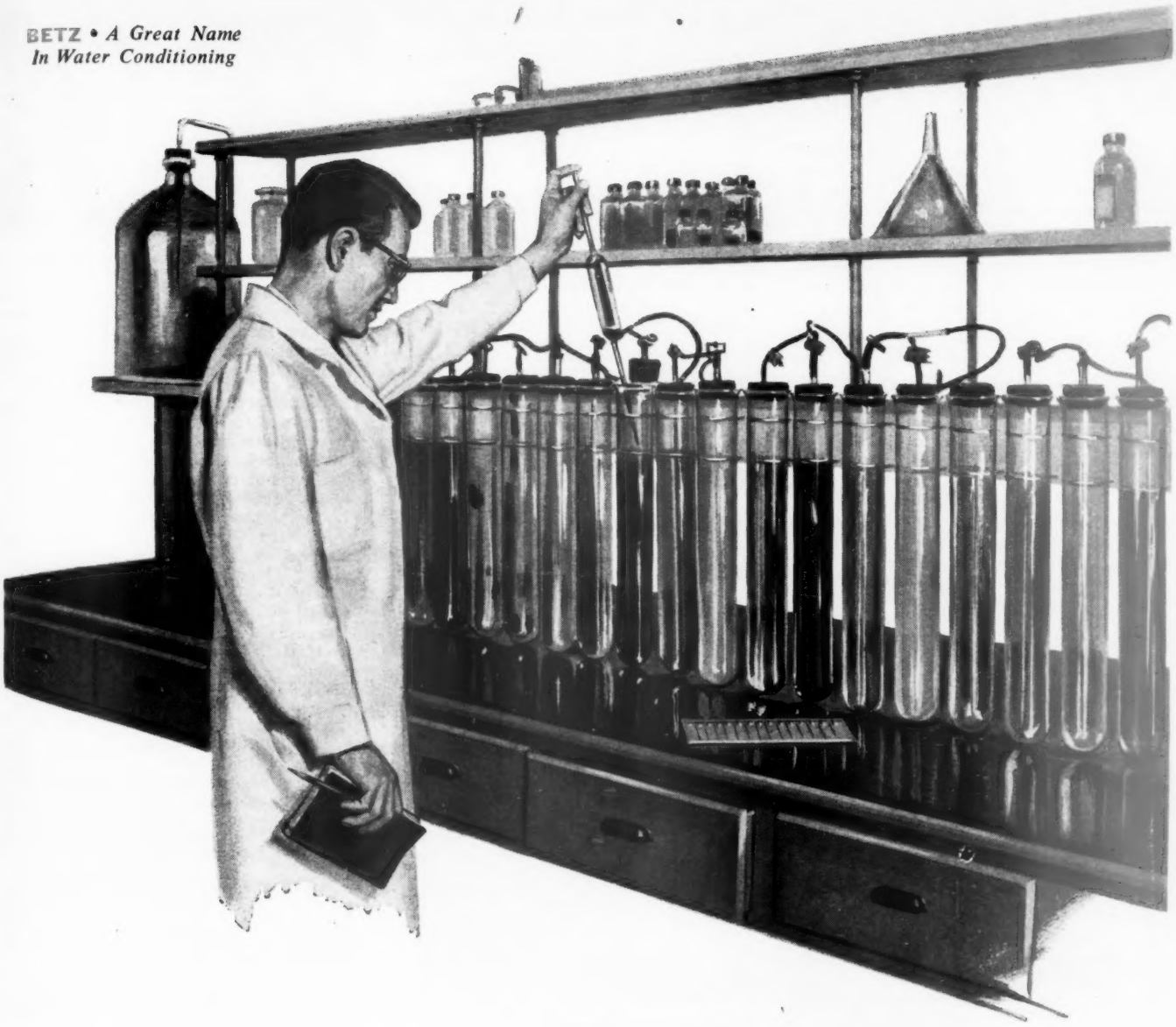
▸ **Lawrence R. Gardner** has been named purchasing manager for Commercial Solvents Corporation.

▸ Appointment of **Joseph A. Lagore** as vice president—manufacturing and **James D. McLean** as vice president—sales of government and industrial division, has been announced by Philco Corporation.

▸ **R. J. "Bob" McGann** has been appointed sales engineer for the Portadrill division of the Winter-Weiss Company.

XUM

BETZ • *A Great Name*
In Water Conditioning



He's researching another first!

Big things are happening daily in industrial water conditioning . . . new developments . . . new discoveries . . . new techniques. As the leader in researching better ways to condition water, Betz is far out in front. The record speaks for itself. For example, Betz was

. . . *first* to develop an advanced method for the *complete* control of corrosion in condensate lines.

. . . *first* to develop an economical technique for the control of corrosion and pitting in recirculating cooling water systems.

. . . *first* to pioneer the use of effective antifoam agents for prevention of carryover.

. . . *first* to develop a practical method of silica removal from boiler feedwater.

These Betz firsts are *just a few* of the many industry-accepted water conditioning methods that have resulted from our *continuing* program of research. Many more are to follow.

Isn't this the kind of leadership and ability *you* want in water conditioning counsel for *your* plant? A Betz District Engineer will be happy to give you the details of Betz complete plant service. Talk to him today.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa.

In Canada: BETZ Laboratories Limited, Montreal 1.

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

To obtain more information on products advertised see Page E-41

Trade Personals

Norman M. Sted, who started his career with American Steel & Wire division as an office boy in Cleveland, Ohio, has been named to a key sales executive position with this United States Steel unit, that of assistant general manager of sales.

Frank H. Dunn, Jr., has joined Frank Wheatley Supply Company as assistant to the manager. He replaced **John R. Fitzpatrick** who will be devoting full time to sales engineering in the field.

Conoflow Corporation has appointed **George S. Edwards** as sales representative for Cono Controls in Alabama.

Jack D. Tolliver has been appointed manager of the recently established sales development division of Tube Turns, Louisville, Kentucky.

John H. Faunce, Jr., has been named director of market and commercial development at Lukens Steel Company.

Wallace A. Altgilbers has been promoted to chief time study engineer and **Thomas E. Rost** to chief draftsman at Edward Valves, Inc., East Chicago, Indiana, subsidiary of Rockwell Manufacturing.

Gil M. Robinson has been added to the sales force of McEvoy Company to give increased sales coverage in the Central Texas area.

Edward M. Welty has just been appointed district manager of the Cleveland office for The H. M. Harper Company.

James D. De Flon has been named chief engineer in the cooling tower division for the Santa Fe Tower and Tank Company.

J. D. Hughes

J. H. Flanagan

James D. Hughes of Lane-Wells Company, and **John H. Flanagan** of Johnston Testers, Inc., have been elected as chairman and secretary-treasurer, respectively, of the Nomads National Board of Regents.

Tube Turns, Louisville, Kentucky, has announced four changes in the company's Western division. **L. O. Morris,** formerly sales representative in Denver, Colorado, has been made the new district manager of the Mid-Continent territory. **Daniel V. Pisano,** formerly a member of the sales staff of the New York office, has been appointed manager of the San Francisco district. **Norton P. Bosemer,** formerly manager of the Los Angeles office and plant, has been moved up to district manager of the Los Angeles territory. **E. R. Muir, Jr.,** formerly sales representative at Seattle, Washington, has been appointed district manager of the Northwestern territory.

The Continental Supply Company has appointed **R. G. Seim** as assistant district manager of its Illinois-Indiana-Kentucky district.

M. W. (Monk) Cook has been appointed a field engineer for Chiksan Company.

Appointment of **Wade W. Hampton** as manager of the southern region, and **Marion A. Foreman,** manager of the Gulf Coast division, has been announced by Hughes Tool Company.

Russell J. Geitman has been appointed chief engineer for Link-Belt Company's plant in San Francisco, California.

D. W. Haering & Company, Inc., of San Antonio, Texas, has appointed **Dan A. Doolittle** as field engineer in the Southern California territory including Los Angeles and San Diego. Doolittle replaced **Paul A. Dobson,** who retired after 15 years' service with Haering.

David K. Tomer has been appointed administrative assistant to the president of Blaw-Knox Company.

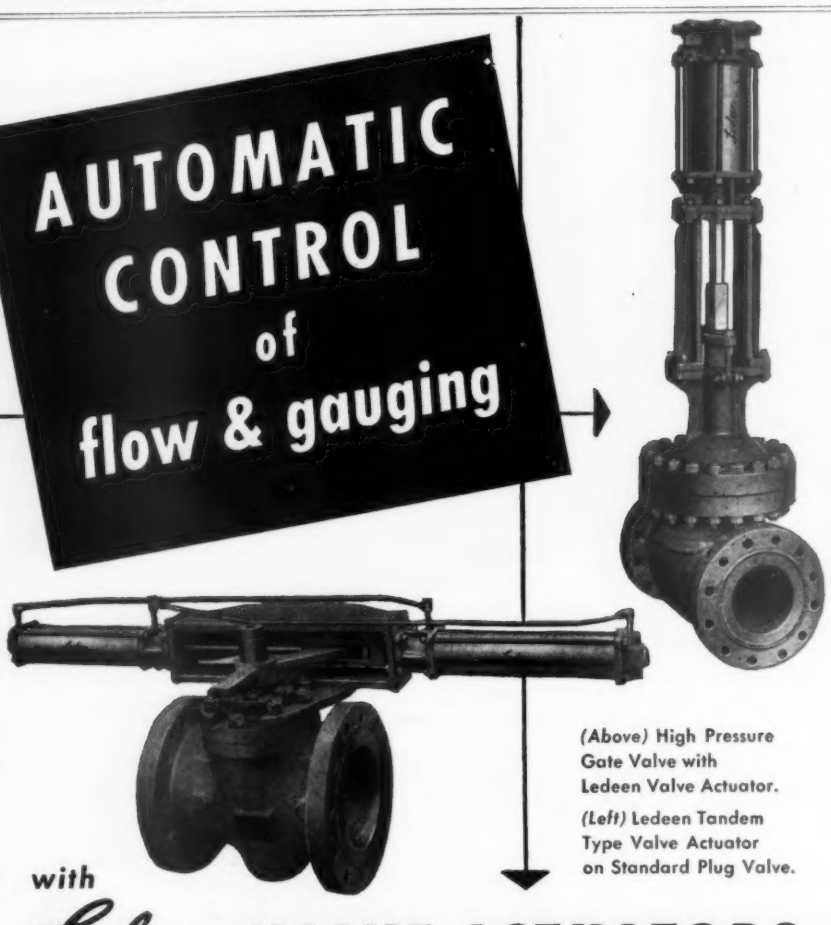
Three Pittsburgh officials of Rockwell Manufacturing Company have been promoted to new management posts. **Norman W. Rowand,** general manager of the Pittsburgh division, has been named assistant to the vice president; and **Paul A. Mankin,** chief engineer of the local division, has been named general manager. **Arthur W. Krause,** assistant general manager, has been named factory manager.

John G. Buechel has been appointed general sales manager of Durabla Manufacturing Company.

Wilfred Sykes has been elected to the board of directors of Lone Star Steel Company.

Paul J. Every has been named assistant general sales manager, Cummins Engine Company, Inc., of Columbus, Indiana.

AUTOMATIC CONTROL of flow & gauging



(Above) High Pressure Gate Valve with Ledeen Valve Actuator.
(Left) Ledeen Tandem Type Valve Actuator on Standard Plug Valve.

with Ledeen VALVE ACTUATORS

★ Simple, Rugged Construction.
★ Few Moving Parts.
★ Easily Installed.
★ Prompt Delivery.

These actuators are for the automatic operation of gate, diaphragm, plug and other line valves, and are pneumatically or hydraulically operated for direct or remote control. Designed as package units, they are mounted directly on the valves without need of special manifolds or outside supports. They are easily, quickly and rigidly installed on new valves or on valves in service.

Ledeen Valve Actuators provide positive operation, permit automatic processing, safety installations, multiple central control ,and require a minimum of maintenance. WRITE FOR BULLETIN 3000.

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VALVE ACTUATORS
AIR HYDRAULIC
PUMPS & BOOSTERS

Ledeen Mfg. Co.
1608 SAN PEDRO
LOS ANGELES 15, CALIFORNIA

M. C. Goforth

P. M. Davis

M. C. Goforth has been appointed sales engineer for Delta Tank Manufacturing Company, Inc.

P. M. "Mack" Davis has been appointed manager of sales-structurals, by Emsco Manufacturing Company.

Eldon N. Wolcott, formerly with Foster-Wheeler Company has joined Bellco Industrial Engineering Company as assistant chief engineer.

Wilson D. Leggett, Jr., formerly Rear Admiral, USN, chief of the Navy's Bureau of Ships, has been appointed vice president of engineering of American Locomotive Company.

B. J. Milleville has been appointed chief engineer at Edward Valves, Inc., East Chicago, Indiana, subsidiary of Rockwell Manufacturing Company.

The Opaco division of Red Jacket Manufacturing Company has appointed **R. M. Crowder** as direct factory representative covering northern and western Texas and Oklahoma. Also appointed as direct factory representative is **Pat Courtin,** who will cover the territory of southeastern Texas.

Two new vice presidents and one assistant vice president have been announced by Hall-Scott Motors Company, Berkeley, California. **Charles S. Herbert** was named treasurer and vice president of finance. **H. L. Lawrence,** formerly works manager and superintendent of production materials and control, was named vice president of manufacturing. **Z. P. Loyd,** a pioneer with Hall-Scott, was appointed assistant to the vice president of manufacturing.

Clifford H. LeBlanc has been named president of Gulf Coast Machine & Supply Company.

Frederick E. Romberg has been appointed manager of the gravity division of Geophysical Service, Inc., of Dallas, Texas. **Dr. Richard A. Geyer** has also joined the staff of the GSI gravity division as chief geophysicist.

George W. Bond has been appointed as purchasing agent for the Construction Service Company.

Hilary A. Humble, for five years product sales manager for cathodic protection activities, magnesium department, The Dow Chemical Company, has been named product sales manager for primary magnesium ingot, magnesium alloy ingot, magnesium extrusion and rolling ingot, flux, and magnesium anodes.

Rainey Elliott has been named president of Jones & Laughlin Steel Corporation.

Ehrhart & Arthur, Inc., Engineer and Constructors, have transferred **Frank Sesler** to Oakland, California, as manager of their Bay area activities.

Royston Laboratories, Inc., Pittsburgh, Pennsylvania, has appointed **E. M. Steinmann** as southeast sales engineer in charge of its new Atlanta, Georgia, office.

Octavius ("Ox") Morgan, general sales manager of Falcon Products, Inc., Pomona, California, has returned from a seven-week business trip through South American countries to visit the active oil fields.

A. A. Porter has been appointed vice president in charge of erecting for U. S. Steel's American bridge division. He succeeded **C. William Doerr** who retired after 42 years with American Bridge.

Francis D. Holden has been appointed manager of sales of Macwhyte Company.

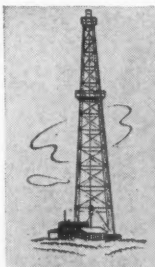
Robert O. Frick has recently been appointed advertising manager of Philadelphia Gear Works.

Jack L. Mershon has been appointed sales manager for Southwest Industries, Inc.

Edward J. Mahoney, Jr., has been elected a vice president of Bechtel International Corporation and of Compania Bechtel, S. A.

Frank Creden has joined the staff of Ruthrauff & Ryan, Inc., advertising agency, New York City.

Hal Farmer has been appointed to the staff of sales engineers of Oil Base, Inc.



WHEELING
COUPLINGS
FOR OIL COUNTRY USE

LINE PIPE COUPLINGS A.P.I.
⅛" to 12" — Seamless and Special Processed — Black or Galvanized

PLAIN TUBING COUPLINGS A.P.I.
1" to 4" — Seamless

EXTERNAL UPSET TUBING COUPLINGS A.P.I.
¾" to 3½" — Seamless

CASING COUPLINGS A.P.I.
4½" to 13⅜"—Long or Short

HYDRAULIC COUPLINGS
⅛" to 4" — Seamless

REAMED AND DRIFTED A.I.S.I.
¾" to 12" — Seamless or Special Processed

DRIVE PIPE COUPLINGS
⅜" to 12" — Seamless or Special Processed

Sales Offices in Leading Cities:

Albany, N. Y.—Albert L. Becker, 434 Clinton Ave.
Baltimore, Md.—Ted Barto, 2301 No. Charles St.
Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Detroit, Mich.—Thomas L. Osberger, 10226 Woodward Ave.
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Houston, Tex.—Henry H. Paris Distributor, Inc., Box 932
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Avenue
Milwaukee, Wis.—M. A. Nelson Co., 3347 N. 97th St.
Minneapolis, Minn.—Lin J. Krause, 5605 Lyndale Ave. S.
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Ira L. Rothenberg & Assocs., Industrial Office Bldg., 1060 Broad St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo.—Mike A. Boyle Co., 1112-18 Hamilton Ave.
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
Seattle, Wash.—Earl H. Jones & Co., 819 Thomas St.

WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA. and WOODLAKE, CALIFORNIA

...Switch to *Visco* BLUE!

● If emulsion breaking chemicals have you over a barrel . . . as to treating cost, handling, or results . . . check *now* with your Visco Man. Or, call MAdison 0433 . . . or write Box 6826, Houston.

We know that a fast, effective Visco formula can be fitted to your problems . . . and will make everybody happy (including us).

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2600 Nottingham at Kirby • Houston 5, Texas

Visco® **CONSISTENTLY EFFICIENT OIL FIELD CHEMICALS**

NEW oil and gas Equipment

- Machinery
- Supplies
- Services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

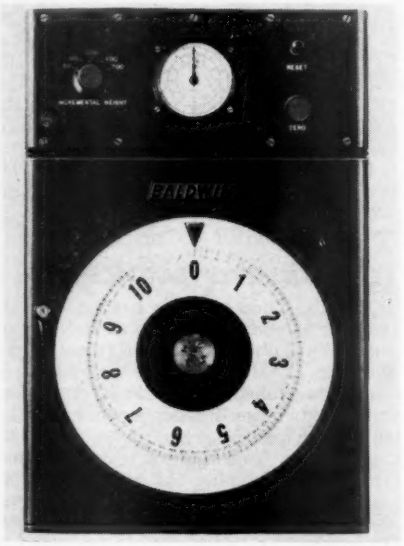
(1) SIMPLIFIED FILTER

Luber-finer, Inc., has announced production of two new Luber-finer units, models 500-C and 750-C. The models, new in the filter industry, were designed to provide simplified, faster pack replacement by use of a clamping ring utilizing a single-bolt closure. They have positive-sealing "O" ring type gaskets to insure leak-proof lid closure at all operating pressures.

Circle number (1) on reply card.

(2) TRANSDUCERS

Baldwin-Lima Hamilton Corporation is producing SR-4 devices for use in automation. The Baldwin SR-4 devices that may be considered as transducers now include (1) load cells for sensing variations of tensional and compressional loads



(some can be used for both), (2) pressure cells for sensing variations of gas or liquid pressure, (3) differential pressure cells, that can be used to sense variations in gas or liquid flow through an orifice plate in a pipe, for example, and (4) torque pickups which sense variations of torque or power in a rotating shaft by the amount of strain in the shaft.

Circle number (2) on reply card.

(3) BACK-OFF TOOL

Safety Engineers Tool Company is producing a new tool for the backing-off of stuck sucker rod strings in oil wells. Called the Curtis Safety Backoff Tool, it was designed to eliminate stripping jobs and can do in five minutes what a crew of four men might take hours to complete, if rod wheels or hand wrenches were used. There are two models of the tool. One is used with an endless rope from a cathead supplying the power and the other to be used with pneumatic or hydraulic power tongs. Outstanding advantages of the tool are its safety to operator and the speed of removing a string of stuck rods.

Circle number (3) on reply card.

(4) SHAFT SEAL

New England Tank & Tower Company has developed a side drive mechanical shaft seal that can be repaired, replaced, or converted to a conventional stuffing box while under a full head of pressure. This design incorporates a secondary seal that temporarily seals off the tank while the mechanical shaft seal is being serviced. The annular area occupied by the mechanical seal permits quick substitution of a conventional stuffing box for the mechanical seal.

Circle number (4) on reply card.

(5) MUD STILL

Geophysical Machine Works has designed the Fann model 54 mud still to determine the oil, water, and solids content of oil emulsion muds. A test may be completed in less than 20 minutes under normal conditions. Instrument is 13 in. high, 7 in. deep, 6 in. wide, and weighs 14 lb.

Circle number (5) on reply card.

(6) SPEE/GEE

Brooks Rotameter Company is producing the Spee/Gee for rapid and accurate determination of liquid densities for continuous sampling and other processing services. A non-spin hydrometer in a special enclosure is placed so that fluid specific gravity may be read at all times. Unit features Brooks full-view safety shielding and side plate construction.

Circle number (6) on reply card.

(7) COATINGS

Teflon dispersion coatings may be bonded to any metal having a melting point over 750 F, except copper, by means of special primers and process developed by E. I. du Pont de Nemours & Company, Inc. The primer and finish coats are fused at a temperature of approximately 700 F after having been applied by spray.

Circle number (7) on reply card.

(8) MAGNESIUM ANODE

Dow Chemical Company has introduced galvomag, a new magnesium anode material supplying 20 to 30 per cent more current than other conventional magnesium anode alloys. Magnesium anodes, because of the inherent electrochemical properties of the material, are used sacrificially to protect steel pipe line and other underground steel structures from corrosion.

Circle number (8) on reply card.

(9) FILTER CARTRIDGE

The Hilliard Corporation is producing a new filter cartridge having increased filtering area, low pressure drop, and high dirt storage capacity. The cartridge is available in two types, F-718 and FW-718, similar in construction but permitting different methods of installation.

Circle number (9) on reply card.

(10) HYDRAULIC HOSE

A new prototype high pressure hydraulic hose designed to operate at 3000 psi and at temperatures never before demanded in hydraulic system has been announced by Resistoflex Corporation. Because of its complete chemical inertness, the new line known as Fluoroflex-T YR700 hose, is designed to withstand all presently known synthetic or petroleum-based hydraulic fluids as well as those which may yet be developed at temperatures over 400 F.

Circle number (10) on reply card.

(11) LOCATING BRIDGE

A new wheatstone and fault locating bridge designed for convenient operation in the field is offered by Electro-Measurements, Inc. Considered to be the most compact fault locating bridge on the market today, this instrument is supplied in a strong, light-weight case that has been completely weatherproofed.

Circle number (11) on reply card.

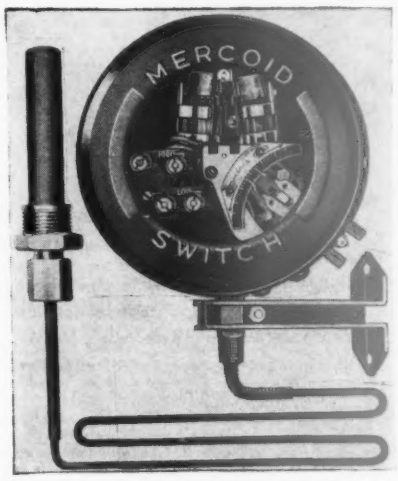
(12) TUBE BENDING

The Parker Appliance Company's model 824 tube bender, a bench-mounted manual bender widely used in fabrication of metal tubing for fluid-handling systems, is now available with a new toggle clamp for easier and speedier operation.

Circle number (12) on reply card.

(13) TEMPERATURE CONTROL

Mercoid Corporation now has available a two-stage temperature control that provides the advantage of staged operation from a single actuating bourdon tube. The

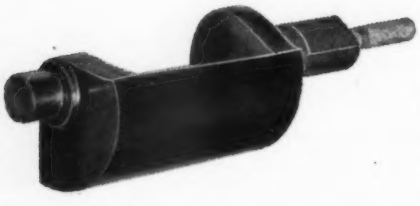


control incorporates two independently adjustable magnetic mercury switches that provide for successive stage operation or high-low operation. The controls can be furnished in 11 different operating ranges. They are equipped with external adjustments and a visible calibrated dial. The switches are magnetic mercury sealed.

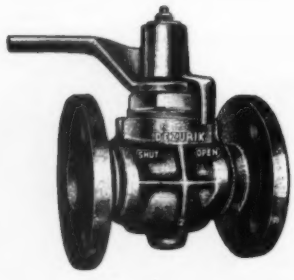
Circle number (13) on reply card.

HERE'S HOW
DEZURIK VALVES ARE DIFFERENT!

It takes only a short, easy QUARTER-TURN to open any DeZurik Easy-Operating Plug Valve WIDE OPEN or close it ABSOLUTELY SHUT. DeZurik's exclusive Eccentric Action provides the smoothest, simplest, surest operation of any plug valve.



The unique DeZurik Plug is rubber-faced on a rigid metal core. This plug delivers a conforming closure against the metal seat, closes 100% drip-tight even with solids intervening, won't ever distort, needs no reseating, no maintenance.



DeZURIK VALVES will excel in a whole range of petroleum process applications: on gasoline and diesel fuel loading racks, lube grease lines, mud lines, refinery gases and bleeder lines to butane and propane kilns.

In sizes from ½" thru 20", in all metals, with lever, gear or cylinder operators. Also available in automatic operated models. Representatives in principal cities. Write for details.

DEZURIK
SHOWER COMPANY
SARTELL, MINNESOTA

New Equipment

(14) GAS METER

A new aluminum die-cast gas meter, believed to have the biggest capacity per pound in the world has been introduced by Rockwell Manufacturing Company. Intended for commercial and industrial services, the new large capacity Rockwell "No. 4" weighs only 176 pounds as compared with 600 pounds for Rockwell's cast iron meter of the same capacity and working pressure. Designed for working pressures up to 100 psi, its overall dimensions are 33 by 27 by 19 in.

Circle number (14) on reply card.

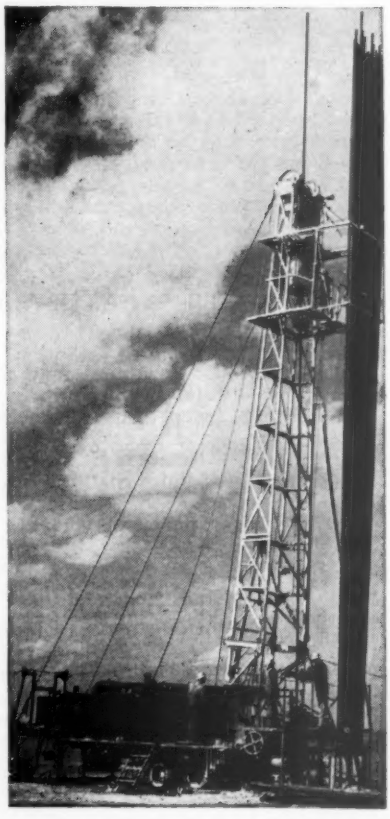
(15) PIPE VISE

Jaws that grip with "rocking wedge" action provide a number of important advantages that are said to be exclusive with the new Toledo No. 1 Pipe Vise, produced by the Toledo Pipe Threading Machine Company. The vise has heat treated jaws and is constructed for heavy-duty use.

Circle number (15) on reply card.

(16) SKYTOP RIG

Skytop Rig Company is producing an open-crowned rig, the Skytop. Height to which pipe can be pulled above the derrick is limited only by the ability of the pipe to remain erect above that point. This new rig, designed and built primarily for slim hole drilling and deep workover, has a 60-ft derrick, and stands pipe back in



63 ft doubles. The derrick has a working hook capacity of 150,000 lb. The standard drawworks is two-speed, double drum, with air clutches, torque converter, and up to 300 hp prime mover. It is recommended for slim hole drilling with 2½-in. tubing and workovers with ⅞-in. drill pipe to 10,000 ft, and for drilling with 3½ in. drill pipe to 5000 ft. The derrick is also adaptable for installation on service rigs for rod and tubing service of wells to any depth. The unit is trailer mounted.

Circle number (16) on reply card.

(17) RADIO EQUIPMENT

The General Electric Company has announced a new line of FM mobile and base station two-way radio communication equipment for both 25-54 megacycle and 144-174 megacycle land-mobile radio services. The line of mobile two-way radio communications equipment was specifically designed, from microphones to speaker, to cover the widely divergent requirements of the numerous land mobile radio services.

Circle number (17) on reply card.

(18) SAFE MOTOR

A new NEMA-specification motor, embodying every requirement to meet the specifications of the National Board of Fire Underwriters and carrying the official Underwriters' seal, is being produced by U. S. Electrical Motors Inc. It is designated as Type E and is made in ratings from 1 to 5 hp. This motor is designed to operate in extremely dangerous locales and is made for Class I, Group D services for highly inflammable gases and volatile liquids, and Class II, Groups F and G for combustible dusts.

Circle number (18) on reply card.

(19) CALIBRATION SYSTEM

A new Flowmeter Calibration System based on time and weight measurements with a standard Baldwin SR-4 Load Cell is announced by Baldwin-Lima-Hamilton Corporation. The instrument is a specially designed indicator-controller in which electrical indications of weight from the load cell start and stop a timer automatically at two pre-set weights of liquid after it flows through the flowmeter to be calibrated into a tank supported by the load cell.

Circle number (19) on reply card.

(20) MULTIPLE BRANCH TEE

A Tube-Turn multiple branch tee with integral extruded outlets has been introduced by Tube Turns, a division of the National Cylinder Gas Company. It makes possible a sound and economical solution to many header problems in the petroleum, chemical, and power fields, and can also be used advantageously in the fabrication of piping for air conditioning and radiant heating systems. The new tee is especially useful where branch outlets are much smaller than run pipe.

Circle number (20) on reply card.

(21) ROTO-SHELF COOLER

A new Roto-Shelf Cooler developed by Buflovak equipment division of Blaw-Knox Company, greatly reduces the space required for continuously cooling and solidifying sulfur. Other products with similar properties may also be solidified by the new equipment. The Roto-Shelf Cooler consists of several circular trays mounted on a vertical drive shaft, each tray operating as a separate cooler.

Circle number (21) on reply card.

(22) THREAD COMPOUND

Fel-Pro C-5 "Hi-Temp" Thread Compound for stainless steel and high temperature applications up to 1800 F, now embodies advancements resulting from over seven years of field experience and engineering research, according to the Felt Products Manufacturing Company. Fel-Pro C-5 is now being widely used to prevent galling and seizing of studs, bolts and threaded assemblies, and as a preventive for galvanic pitting of stainless steel.

Circle number (22) on reply card.

XUM

(23) VAPO-GARD

The Enardo Manufacturing Company has announced the manufacture of a new tank valve called the 770 Vapo-Gard. The new valve is of die-pressed steel construction, has a pressure-energized sealing gasket, and incorporates many new safety features.

Circle number (23) on reply card.

(24) PUMP BODY

A new high pressure fluid pump body designed by 20th Century Manufacturing and Supply Company is suited for hydraulic fracturing, chemical acidizing and cementing of oil and gas wells. Made of forged steel, it was designed to increase production and hold down rig time.

Circle number (24) on reply card.

(25) OXYGEN ANALYZER

Arnold O. Beckman, Inc., has announced an addition to its line of oxygen analyzers. The new instrument—designated the Model C2P oxygen analyzer—is particularly designed for applications requiring a quick, simple, accurate means of measuring oxygen with a portable instrument.

Circle number (25) on reply card.

(26) TURBINE ENGINE

Solar Aircraft Company is manufacturing the 500-hp Jupiter gas turbine engine. The Jupiter is designed specifically for long life with relatively low rotative speeds and moderate stresses. Engine weighs about 1¾ lb for each horsepower produced, has a full load specific fuel consumption of 0.90 pb per hp-hr.

Circle number (26) on reply card.

(27) EXPANSION JOINTS

Rubber expansion joints specially designed for use with piping and flanges made by Haveg Corporation and The Duriron Company, Inc., have been announced by The Garlock Packing Company. These expansion joints are made of a high-grade rubber compound combined with plies of sturdy cotton duck and reinforced with steel wire.

Circle number (27) on reply card.

(28) NONUPLEX PUMP

Aldrich Pump Company announces the availability of its new line of 6-in. stroke Nonuplex Direct Flow pumps for heavy duty pumping applications. These 9-plunger reciprocating pumps offer advantages of positive displacement, high speed operation, compact construction, interchangeability of parts, low maintenance, and minimum discharge variation.

Circle number (28) on reply card.

(29) D8 TRACTOR

A new D8 Tractor—offered in two models—has been introduced by Caterpillar Tractor Company. The two D8 models have different drives—a torque converter (Series D) and a direct drive (Series E)—making this established earthmoving workhorse even more versatile on construction, mining, logging and agriculture jobs.

Circle number (29) on reply card.

(30) STEEL-CORE WIRE ROPE

Roebling is producing a new line of wire ropes, with steel cores, said to have 15 per cent greater strength than the strongest grade marketed heretofore. The new rope will be manufactured primarily in preformed constructions and is designed to allow the handling of heavier loads for longer periods, as well as the drilling of deeper wells.

Circle number (30) on reply card.

(31) TACHOMETER

A redesigned circuit is now put in all Metron single range and triple range tachometers. Under normal conditions this new electrical circuit is said to lengthen the life of these tachometers about five times. The new electrical circuit is linear with single and multiple range indicators that can be calibrated in any units per time.

Circle number (31) on reply card.

(32) FLOMAX 8

The Marine Products Company has introduced Flomax 8 two-inch self-priming centrifugal pump. In cast iron construction this new unit weighs 74 lb and delivers 8400 gal per hr at 25 ft total head including a 10 ft suction lift. The Flomax 8 is powered by a four-cycle Briggs and Stratton engine with remote throttle control.

Circle number (32) on reply card.

(33) TWIN SEAL

The Kerotest Manufacturing Company of Pittsburgh, Pennsylvania, has recently announced an improved model of the twin seal, a non-lubricated plug type valve. The valve is primarily designed to afford a vapor-tight shutoff of both valve ports when handling volatile liquids and gases. However, it has application handling all types of petroleum products.

Circle number (33) on reply card.

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Write for Catalog

ARMSTRONG BROS. TOOL CO.

"The Tool Holder People"

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(34) NEW ATTENUATOR

A new tri-plate variable attenuator has been developed by Sanders Associates, Inc., for use in coaxial lines. Tri-plate constructions makes use of a movable resistive card sandwiched within a new type of printed circuit transmission line.

Circle number (34) on reply card.

(35) CHART PAPER

Perfection of a new type chart paper with special properties that improve the legibility of instrument records has been announced by The Foxboro Company. The new Humitex circular and strip charts are printed under controlled humidity conditions on a white sulphite sheet, meeting rigid standards of uniformity.

Circle number (35) on reply card.

(36) MECHANICAL SEALS

A new type BJ mechanical seal for high pressure boiler feed pumps designed to stop liquid loss, reduces heat loss and requiring no operating adjustment, is announced by Byron Jackson Company. These seals are now in operation in a number of high pressure, hot water pumping operations.

Circle number (36) on reply card.

(37) AIR FILTER

The model F-1 air filter, recently developed by Conoflow Corporation, was designed for filtering air in pneumatically operated apparatus such as instruments, air tools, and spray painting equipment. Of all-brass, it has a center-bolt design for easy removal of filtering element.

Circle number (37) on reply card.

(38) MINERAL WOOL

A new, white insulating-finishing cement, said to be the whitest mineral wool cement now available, is announced by the Baldwin-Hill Company. Called Super Powerhouse Cement, the new material provides both insulating properties and a smooth, white finish when applied alone or over regular insulating cement, block, blanket and other forms of thermal insulation.

Circle number (38) on reply card.

(39) BARREL HOOK

A new all-position barrel hook has been added to the safety tool line of Ampco Metal, Inc. This utility tool has a sliding ring which can be locked between links. This feature allows the drum to be either lifted or tilted for emptying. Overall length of the hook is reduced from 47 to 42-in., providing for greater head-room when loading or unloading drums from storage racks.

Circle number (39) on reply card.

(40) DRILLING MAST

Emsco Manufacturing Company has designed and built the B-127 portable drilling mast. The mast is of open-faced design and has a 416,000 lb nominal gross capacity. It is designed to provide maximum portability, along with a sound, rigid structure.

Circle number (40) on reply card.

(41) AIR-OPERATED PUMP

A new Hills-McCanna pump that takes its power from a double acting air cylinder has been announced. Designed for use in the metering and proportioning of small volume flows, the "UP" pump utilizes the same liquid end components as the series "UM" Hills-McCanna pumps except that plant air supplants a motor drive.

Circle number (41) on reply card.

(42) ROLLER KELLY BUSHING

Baash-Ross Tool Company has announced an important advancement in the design of its 2RS (for square kellys) and 2RH (for hex kellys) roller kelly bushings. In place of the bronze sleeve bearings formerly used between the rollers and the pins upon which they rotate, each large roller now rotates upon individual roller bearings.

Circle number (42) on reply card.

(43) COMPARISON BRIDGE

Southwestern Industrial Electronics Company has announced a new model of its comparison bridge, to be designated the E-2. The instrument can now be operated by means of an optional foot switch, as well as by the conventional push button. An addition to its use as a comparator and go-no-go gage, the E-2 may be combined with a decade box to make quick measurements of absolute values.

Circle number (43) on reply card.

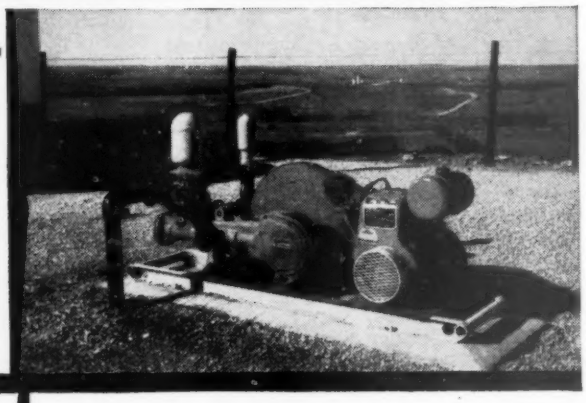
(44) WATER PRESSURE UNIT

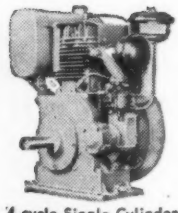
The EPCO pumper, designed by Eastman Pacific Company, is a complete unit, including power supply, pump, and filter for supplying fresh or salt water at 300 psi at the rate of 7 gpm. Model GMS, powered with a 1.6 hp gasoline engine weighs 30 lb and is easily portable.

Circle number (44) on reply card.

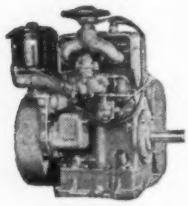
Efficient, Self-Sufficient

WISCONSIN-POWERED Pumping Unit on Duty in Cattle Country

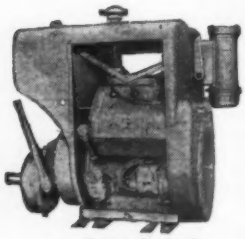




4-cycle Single Cylinder 3 to 9 hp.



2-cylinder 7 to 15 hp.



V-type 4-cylinder 15 to 36 hp.

Here is a Wisconsin-Powered oil pumping unit that is as *efficient* as it is *neat*. A standard Model AKND single cylinder Wisconsin Heavy-Duty Air-Cooled Engine operates a Goulds Reciprocating pump, delivering dependable, all-weather service the year 'round.

This installation is typical of the extremely compact, self-sufficient, foolproof Wisconsin-powered pumping units extensively used in oil field service. The unit shown above is working in the rich, active Little Chief Field of Oklahoma, where new, prolific producers are being developed. This is primarily cattle country and it is hazardous to have surface waste oil accumulations, so all oil is treated and re-treated — and it is in connection with this operation that this rugged Wisconsin-powered pumping unit is used.

Wisconsin Air-Cooled Engines used in heavy-duty oil field service are equipped with Stellite Exhaust Valves and Valve Seat Inserts and positive type Valve Rotators, assuring long engine life and lowest cost maintenance. Let us tell you about many other special oil field features.

More oil field utility units are powered by Wisconsin Heavy-Duty Air-Cooled Engines than any other make within a 3 to 36 hp. range — dominant preference that is based on actual performance records. You can't do better than to specify "Wisconsin Power" for *your* oil field equipment.

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XUM

NEW oil and gas Literature

- **Brochures**
- **Bulletins**
- **Catalogs**

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(45) BLADES

International hydraulic Bullgrader and bulldozer blades matched to International T-6, TD-6, T-9, TD-9, TD-14A and TD-18A crawlers are described in a 24-page catalog published by International Harvester Company. The bulldozer blade assembly is solid welded without pin connections, providing a rigid, level blade. The Bullgrader blade, connected by pins to the main frame, may be horizontally angled or vertically tilted.

Circle number (45) on reply card.

(46) AIR POWER SYSTEM

A new engineering service bulletin, *A Better Air Power System*, is available from Ingersoll-Rand Company. It points out that power losses in compressed air lines are sometimes as much as 30 to 50 per cent and describes how to go about finding out if more air is being wasted than the repair and renovation of the distribution system would cost.

Circle number (46) on reply card.

(47) G-E BUYER'S GUIDE

The 1955 edition of the G-E Instrument Transformer Buyer's Guide, containing basic, up-to-date information on the complete General Electric line, has been published. The 100-page publication, designated GEC-1028, contains ratings, ASA accuracy classifications, and prices of all Standard G-E indoor and outdoor potential and current transformers.

Circle number (47) on reply card.

(48) SWITCHGEAR

Metal-clad switchgear rated 2.4 kv to 13.8 kv and 50 to 500 mva is described in General Electric Bulletin GEA-5664C. Four-color 52-page publication includes detailed discussion of applications, installation, maintenance, advanced design features, accessories, etc. Bulletin gives tables, foundation data, and guide form specifications.

Circle number (48) on reply card.

(49) THERMOCOUPLES

A new edition of their 56-page Bulletin P1238 on thermocouples and pyrometer accessories has been published by The Bristol Company. The bulletin contains extensive engineering data on the selection and installation of the proper types of thermocouples, wells, head assemblies, and other pyrometer accessories.

Circle number (49) on reply card.

(50) UNIMOUNT MOTORS

A multicolor bulletin, graphically illustrating the improved types of U.S. vertical solid shaft motors, has been prepared by U.S. Electrical Motors Company. It includes Unimount vertical motors in ratings from ¼ to 400 hp in grease and oil lubricated types. Cross-sectional views portray the details of design and many special features are presented.

Circle number (50) on reply card.

(51) MARINITE

Marinite For Driers, Ovens, Breechings and Housings is a new 16-page, illustrated booklet just issued by Johns-Manville. The booklet gives handling and working recommendations; construction and fabrication suggestions; data on physical and thermal properties; and, many photographs showing how Marinite is being used by the textile, food, plastics, appliance, electronics and petroleum industries.

Circle number (51) on reply card.

(52) BRAZING MANUAL

The Air Reduction Sales Company has published a 24-page brazing manual. It is especially concerned with the application of the major brazing methods in joining metals using silver alloys and filler metals, fluxes, and gas atmospheres.

Circle number (52) on reply card.

(53) PRESSURE CONTROLLER

Bulletin 7404 issued by Minneapolis-Honeywell Regulator Company describes the Honeywell indicating furnace pressure controller and its uses in measuring and controlling furnace operation.

Circle number (53) on reply card.

(54) RELIEF VALVES

A new 20-page catalog, No. 5200, describes and illustrates the Cochrane multiport relief valve. Publication also describes service records established by multiport relief valves. Three styles of valves are illustrated, together with construction features.

Circle number (54) on reply card.

(55) SPECTROMETER

Data Sheet 10.16-19 describes the RIDL model 2300 scintillation spectrometer, made by Radiation Instrument Development Laboratory and its use with the Brown ElectroniK strip chart potentiometer to provide a completely automatic scintillation spectrometer.

Circle number (55) on reply card.

(56) PROCESS PUMPS

A new bulletin on Type HMC, integral seal process pumps, single stage vertical split, has been issued by Worthington Corporation. It furnishes information on refinery HMC process pumps with integral mechanical seal.

Circle number (56) on reply card.

(57) AIR, GAS DRILLING

A new service manual published by Shaffer Tool Works outlines the principal feaures of air and gas drilling procedures, shows typical installation hook-ups, gives case histories of gas-drilled wells in the Farmington, New Mexico, fields and air-drilled wells in the Ventura, California, fields. In addition, it contains a section on reverse circulation drilling.

Circle number (57) on reply card.

(58) MINERAL SHOT

A four-page, two-color technical bulletin published by Baldwin-Hill Company describes the characteristics and performance of the company's non-metallic, dustless Mono-Kleen mineral shot for blast cleaning.

Circle number (58) on reply card.

(59) OAKITE CLEANER

Oakite Compound No. 85, designed to remove hard carbon, iron oxide, and sulfide deposits from towers and heat exchangers, is the subject of a service report recently published by Oakite Products.

Circle number (59) on reply card.

(60) FILTRATION

The first in a series of news bulletins on porous media and filtration engineering has been published by the Pall Filtration Companies. Named "Poro-Scope," the new bulletin will be published bi-monthly for research, design, development, and process engineers.

Circle number (60) on reply card.

(61) FLOW INDICATORS

Data Unit No. 253 describes, illustrates, and gives specifications on Jerguson Gage and Valve Company's line of transparent and reflex sight flow indicators for use on any pipe line ½ to 2 in. NPT.

Circle number (61) on reply card.

(62) GAS COMPRESSORS

Joy Packaged Gas Compressors has been issued by Joy Manufacturing Company. The eight-page, two-color bulletin, No. A-94, shows illustrations of several gas compressors in operation in such duties as gas-gathering, repressuring, and gas-lifting.

Circle number (62) on reply card.

(63) WROUGHT IRON

Wrought Iron Pipe Catalog, a 52-page manual has been published by the A. M. Byers Company. It contains technical information required by architects, engineers, piping contractors, builders, maintenance superintendents.

Circle number (63) on reply card.

(64) PIPELINING

Profitable Pipelining is the title of a 12-page booklet produced by Caterpillar Tractor Company. Features in the booklet are large photographs depicting all phases of pipe line operation including clearing, stringing, ditching, lowering-in, and backfilling.

Circle number (64) on reply card.

(65) CATALYST

The Davison Chemical Company division of W. R. Grace & Company has issued revised product data sheets on powdered and pelleted vanadia oxidation catalysts and on indicating silica gel.

Circle number (65) on reply card.

Trade Literature

(66) LIQUID METERING

A six-page bulletin (O. G. 454) issued by Rockwell Manufacturing Company describes Rockwell methods of industrial liquid metering with multistage quantity control valves, which are available in iron, steel, 316 stainless and bronze.

Circle number (66) on reply card.

(67) AMERCOAT NO. 87

Amercoat Corporation has published a bulletin describing Amercoat No. 87 vinyl mastic which can be applied at thicknesses up to 10 mils in one coat. It is designed to give a continuous coating over rivets, welds, angles, and edges which are difficult to coat with thinner materials. General, physical, and chemical properties are given with a guide for ordering.

Circle number (67) on reply card.

(68) CHEMPUMP

Chempump Bulletin 1010 presents detailed data on the expanding line of sealless, leakproof Chempump centrifugal pumps. In 16 pages, it gives information on sizes, horsepowers, heads, and capacities, dimensions, materials of construction, design data, construction features and direct user benefits.

Circle number (68) on reply card.

(69) DUCTILE IRON

International Nickel Company has published Bulletin DI-25 on ductile iron — the cast iron that can be bent. This 30-page illustrated booklet includes case histories, specification tables for the seven main types of ductile irons, and charts comparing mechanical properties.

Circle number (69) on reply card.

(70) SANTOLENE

Santolene C, Monsanto Chemical Company's "single treatment" rust and corrosion inhibitor for petroleum products, is the subject of a booklet published by the company's organic chemicals division.

An ashless organic liquid, the material is designed to prevent rust and corrosion problems in clean petroleum products at concentrations of from 10 to 40 parts per million, depending on the corrosiveness of the product.

Circle number (70) on reply card.

(71) SINTERED BRONZE

Facts about sintered bronze's use in petroleum and natural gas processing and bulk handling are available to the industry in a 16-page catalog published by the Permanent Filter Corporation. The catalog includes basic information of porous bronze as a filtering medium, engineering data on filters already being produced for fuels, oil, and hydraulic fluids used in conventional, jet and rocket aircraft, plus ground applications in the aircraft and other industries.

Circle number (71) on reply card.

(72) LEROI ENGINES

Le Roi division, Westinghouse Air Brake Company, has published, a bulletin describing and illustrating the 115- to 410-hp Le Roi L3000, H2000, and F1500 engines. The eight-page bulletin uses cutaway views and photographs to show advanced features such as modern valve-in-head design.

Circle number (72) on reply card.

(73) CRANE-EXCAVATOR

Bulletins combining complete descriptions and specifications of the Wayne full ¾-yd crane-excavator have been released by the Wayne shovel and crane division of the American Steel Dredge Company, Inc. In addition to specifications and lifting capacities, Bulletin No. 424 describes features of the model 70 crawler-mounted Wayne machine. Bulletin No. 425 contains specifications, lifting capacities, and overall dimensions of the 50A and 50B truck-mounted Wayne models.

Circle number (73) on reply card.

(74) WIRE ROPE

A new bulletin "Ropeology," has been published by MacWhyte Company, describing special uses for wire rope. They include a new cable type overhead conveyor system, an automatic safety device for scaffold workers, a test of tires, logging operations, handling steel bar stock, boat slings, and well drilling.

Circle number (74) on reply card.

(75) ALNOR THERMOMETER

The Buchen Company has released Bulletin 1465 describing the new Alnor distant reading thermometer. It is a compact panel instrument designed to bring many readings from widely scattered temperature zones to a central point — from as far as 1000 ft away.

Circle number (75) on reply card.

(76) TUBING

Bulletin 414, published by Spang-Chalfant, describes its line of extreme tubing. Uses of the tubing in producing strings in deep high-pressure wells are illustrated.

Circle number (76) on reply card.

(77) SERVICE MANUAL

Shaffer Tool Works has compiled and published an informative 36-page service manual on the installation, maintenance and servicing of Shaffer hydraulic cellar control gates, Shaffer hydraulic power units and Shaffer hydraulic panels. Manual is illustrated with cutaway views, exploded parts illustration, and hook-up diagrams.

Circle number (77) on reply card.

(78) PARKERSBURG UNITS

The Parkersburg Rig and Reel Company has published a booklet on its Hyreco processing units. Described and pictured are stabilizer, PQ hyreco units, cold separation units, knockouts, etc. Colorful booklet has photographs, flow diagrams and graphs.

Circle number (78) on reply card.

(79) CARE OF VALVES

Bulletin V-218 Rev. 1 has been published by Rockwell Manufacturing Company to give instructions on lubricating and servicing Rockwell-Nordstom valves. Step-by-step directions, illustrated with photographs, are given.

Circle number (79) on reply card.

(80) DRILLING MUD THINNER

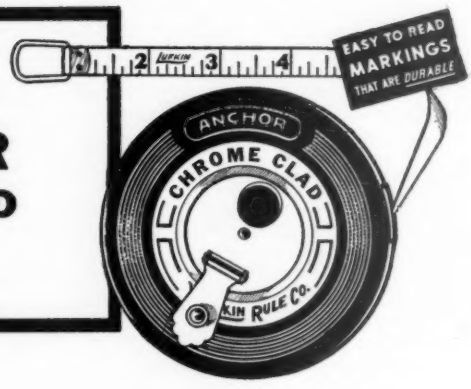
A bulletin has been released by Baroid Sales division giving information concerning the use of its tannin drilling mud thinner, Man-Tan. General specifications, major advantages, and data on wells drilled are given in the four-color bulletin.

Circle number (80) on reply card.

No-glare, easy reading — the oil industry's favorite for years . . .

LUFKIN

ANCHOR CHROME CLAD STEEL TAPE



Jet black markings on the Lufkin "Anchor" Chrome Clad are bonded to the tempered steel line and stand out sharp and clear against the no-glare, chrome-white background. The "Anchor" is strong, and durable too, because the line is built up with a series of platings for extra protection and strength. Genuine leather, mahogany-colored, is hand-stitched over rust-resistant metal case liner. Folding flush handle opened by push pin. A fine tape combining strength, durability, accuracy and beauty. Available with graduations either in feet, 10ths and 100ths; or feet, inches and 8ths.

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Trade Literature

(81) RETARD ACID

Dowell, Incorporated, has published "The Acidizer," discussing increased production obtained by retreatment with retarded acid. Problems, methods, and results are given. Photographs show the action of regular and retarded acid on a concrete block.

Circle number (81) on reply card.

(82) AUTOMATIC CONTROLS

Zenith Electric Company has published a bulletin giving its complete line of automatic control equipment. Drawings and specifications are given for each unit.

Circle number (82) on reply card.

(83) STAINLESS STEEL

Complete details on Carpenter 7Mo stainless tubing and pipe are contained in a new product bulletin issued by the alloy tube division of The Carpenter Steel Company. The alloy is described by analysis, physical characteristics, and mechanical properties.

Circle number (83) on reply card.

(84) FAN BULLETIN

Details on cooling tower and heat exchanger fans manufactured by the Hartzell Propeller Fan Company are included in bulletin A-111A. Among the features are specifications and construction details on the tapered-blade design now being used on Hartzite plastic fans in 14- to 20-ft diameters and on a new line of plastic-impregnated wood blades for fans in the same size range.

Circle number (84) on reply card.

(85) POWER EQUIPMENT

Link-Belt Company has published a 340-page indexed guide to one of the most complete standard lines of power transmission and conveying equipment available. Book contains information for the engineer or layout man in selecting standard products for new installations or for replacements. It includes data on complete line of chains.

Circle number (85) on reply card.

(86) MARINE ENGINES

Lister marine diesel engines with one to six cylinders and 9 to 54 bhp at 1800 rpm are presented in a 4-page illustrated Bulletin No. 448 by The National Supply Company. Design features, accessories, performance curves, and dimensional diagrams are included.

Circle number (86) on reply card.

(87) PARALLEL SHAFT GEAR

A complete line of parallel shaft gear drives is described in this new 32-page book published by Link-Belt Company. Listed are 39 standard size single, double, and triple reduction drives, permitting a standard ratio selection from as small as 1.2:1 to as large as 323:1, with horsepower capacities of over 2000. This book also contains engineering data, including simplified horsepower tables, dimensions, and overhung load capacities for selection from the standard line.

Circle number (87) on reply card.

(88) ENGINEERING SERVICE

Southern Operating and Construction Company has published a brochure describing the engineering and construction services offered by the company.

Circle number (88) on reply card.

20 Bell Holes Like This in One Day with a SHERMAN POWER DIGGER!

"Pay for themselves faster than most of our other equipment!" That's what R. Mannino & Sons, Westfield, New Jersey general contractors say about their Sherman Power Diggers.

A typical Mannino job was for the local gas company. Replacement of clamps and seals on gas mains required digging a series of bell holes. The Sherman Power Digger reduced digging time for the average bell hole to about fifteen or twenty minutes, making it possible to replace as many as twenty clamps a day.

If you now excavate by hand, or if your heavier equipment cannot work in tight spots, you, too, will find the versatile Sherman Power Digger practical and profitable. It's compact, flexible, fast, easy to operate. It digs in a fraction of the time and cost of manual labor—as deep as 10′ below grade in mud, hard-pan, shale, oiled roads, blacktop and stony ground.

Initial cost of the Sherman Power Digger is surprisingly low, maintenance simple and inexpensive. Write today for the whole story. Ask for Bulletin No. 1615.

Designed, Engineered and Manufactured Jointly by
SHERMAN PRODUCTS, Inc.
Royal Oak, Michigan
WAIN-ROY CORPORATION
Hubbardston, Mass.

Patent No. 2,303,852
Other patents pending
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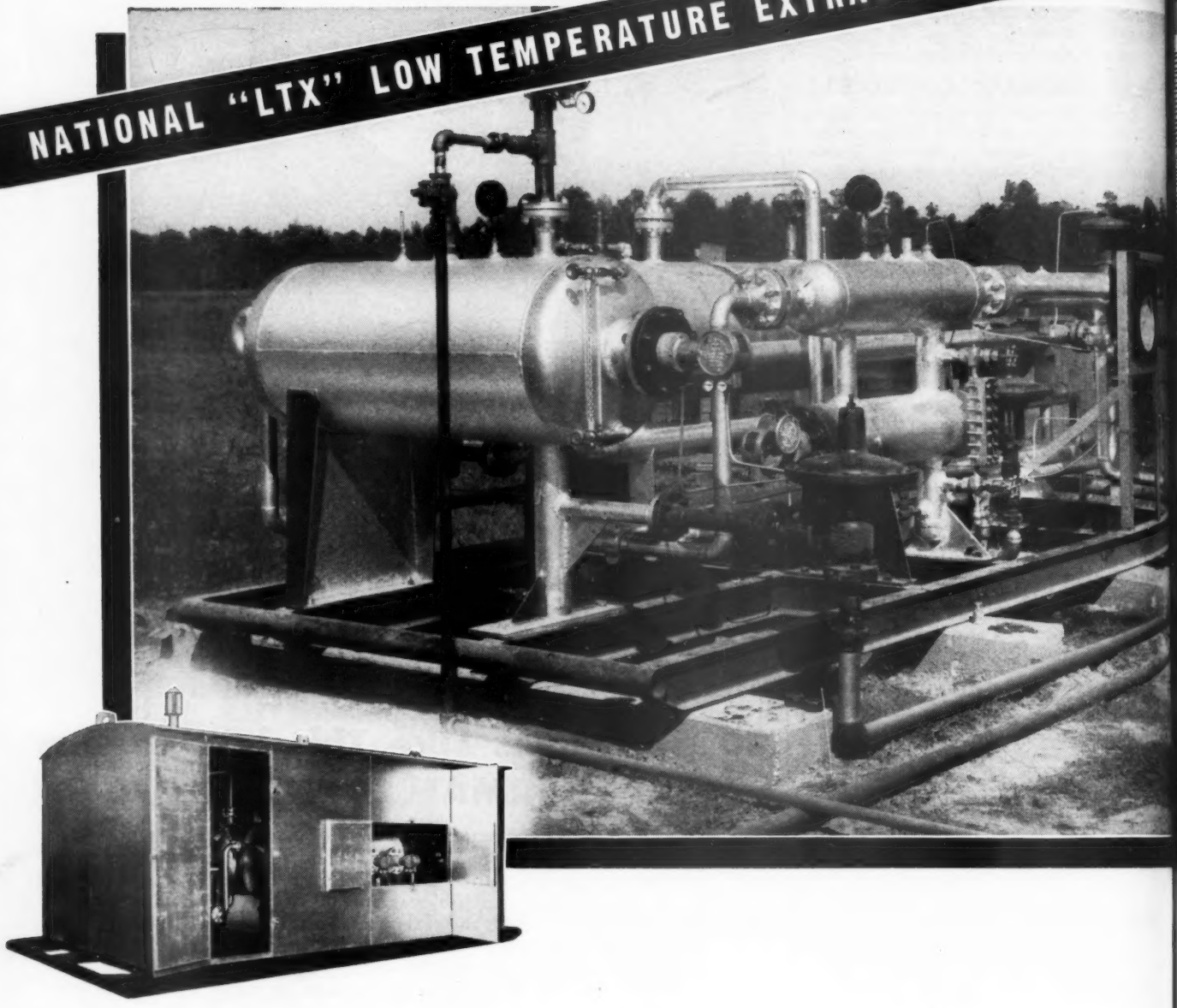
Sherman
PRODUCTS, INC.
ROYAL OAK, MICHIGAN
Sherman SP Products

NATIONAL "LTX" LOW TEMPERATURE EXTRACTION UNITS



Products engineered by National Tank Company are so designed that they become universal for the task they are appointed to do. "Universal" because they are not tailor-made to fit only one set of conditions. They will do the work on many jobs within their rated maximum capacities.

Many "Firsts" have come from "National" — One of the Latest Firsts is the LTX — Low Temperature Extraction Unit.

National LTX Units Produce Maximum Results at Minimum Costs: 1. Maximum Pressure and Flow Stream Recovery of Stable Distillate. 2. Minimum Water Dew Point of Final Gas Stream; Minimum Hydrocarbon Dew Point.

National LTX Units are made in various sizes and capacities.

Write for further information.

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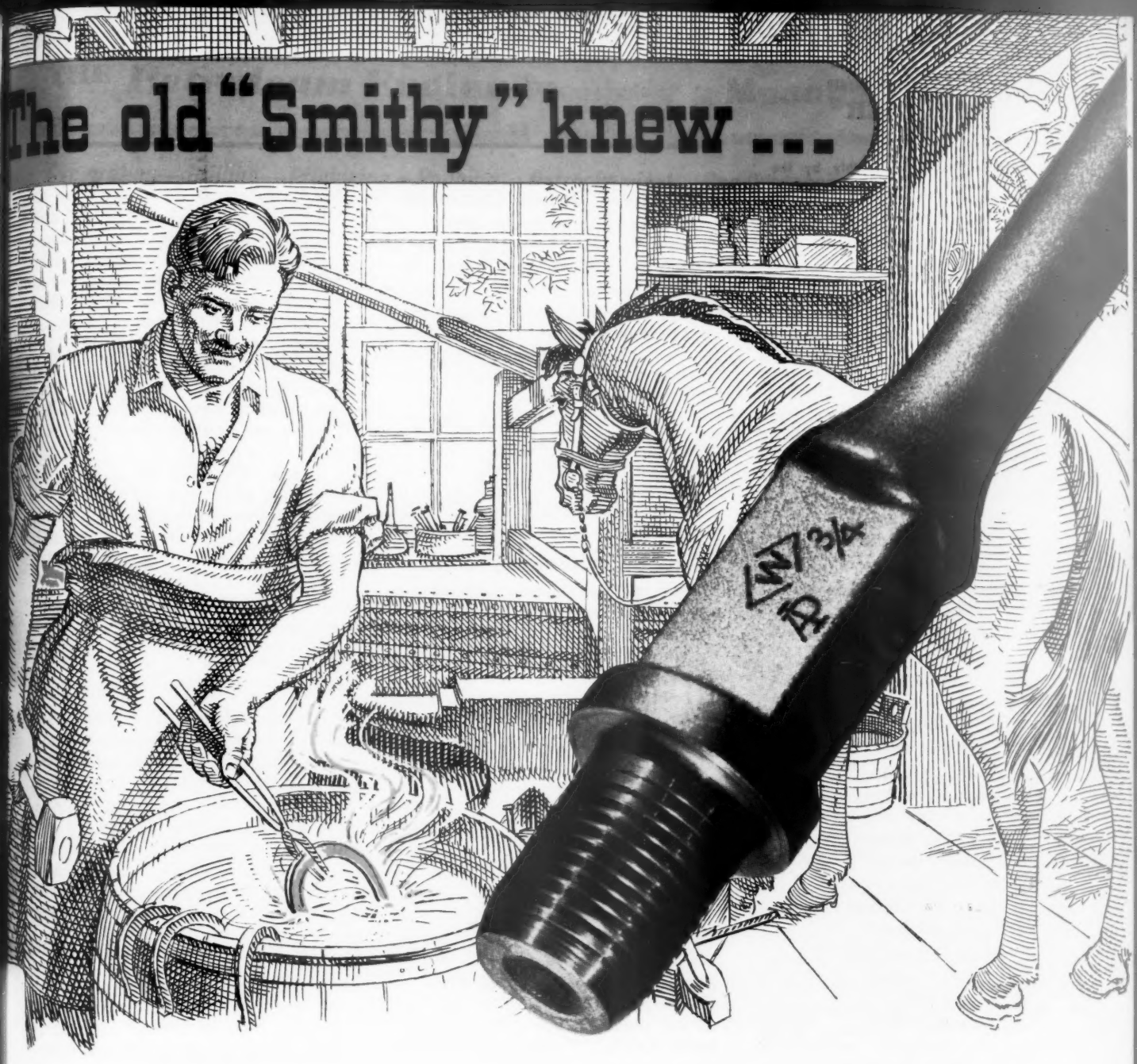

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THE *Petroleum* ENGINEER

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LETTERS

'Additives' Draws Comment

I would like to thank Mr. C. M. Larson for his interesting review of "Additives for Fuels and Lubricants," which appeared in the March issue of *The Petroleum Engineer*. I am new in the petroleum industry and his article was particularly useful in giving me an overall picture of the additive situation.

Nathaniel L. Remes

The Pure Oil Company
Research and Development Laboratories
Crystal Lake, Illinois

Decimal System Explained

I have only recently subscribed to *The Petroleum Engineer*, but the time has been long enough to appreciate the benefits to be derived from the magazine.

I notice that your articles are usually numbered with what appears to be some decimal equivalent to the library classification system. Has this petroleum library decimal classification been published, and if so, how may I obtain a copy?

James H. Brannigan

Reed City, Michigan

Note: *We use a form of the Dewey Decimal System prepared by Lester C. Uren and published in book form by the University of California Press under the title "Decimal System for Classifying Data Pertaining to the Petroleum Industry." Copies may be secured from them at $2.50 each.*

Peake Profile Praised

I was greatly pleased to read the Petroleum Profile, this morning, in the May issue of my favorite oil publication.

There are a lot of us old Salt Creek hands scattered all over the Rocky Mountains and other parts of the world whose background has some of A. W. Peake written on it. I'm sure that you will receive many letters from Midwest, Edgerton, Casper, and Denver telling you how much it means to read about the man whose name is still on street signs and the High School Gym at Midwest.

His electric plant still pumps some 1000 wells—and no one knows how much of the 370 million bbl from Salt Creek Field has been pumped by this method.

I can remember the dedication of the Gym, across the street from the High School in 1925, with a well drilling within 50 ft of the entrance doors.

Mr. Peake also ramrodded the High School lighted football field, which was the world's first lighted field. Wheels from all the electric companies in the East came out to see the lights hung from derricks and tanks that were on all sides of the playing area. I'm sure that this one part of his Salt Creek story would make a very interesting write up.

Thank you again for making me remember Mr. Peake and all the others in the Midwest Refining Company who had such a personal interest in those of us who were getting our book-larnin' at Midwest High.

Larry Conner

Denver, Colorado

'Best' . . . Even in Venezuela

For many years I have been a consistent reader of your magazine and I believe it is the best publication in regard to the oil industry. It is a great and inexhaustible source of information to the petroleum engineer. I wish to take this opportunity to congratulate you for all the efforts you have made and continue making in providing us with a such so good magazine.

Dr. Guillermo José Salas

Cía Shell de Venezuela, Ltd.
Maracaibo, Venezuela, S. A.

Canadian Student Writes

Please send me a copy of *The Petroleum Engineer* editorial index for 1954. I am presently taking my 3rd year of Petroleum Production Engineering at the University of Alberta and find the articles in *The Petroleum Engineer* to be very helpful and interesting.

I and my fellow students at U of A (which by the way is the only college in Canada offering a course in Petroleum Engineering) found the Canadian Issue (February 1955) to be of special interest since we are least vaguely familiar with many of the fields and problems dealt with therein. The information service via business reply card offered by *Petroleum Engineer* is also appreciated.

Thanks for a good quality magazine and hoping for more articles on Canadian problems in the industry.

Donald Kesteven.

Edmonton, Alberta,
Canada